

# A Factorial Study of Adolescent Thought Using Piaget Type Tasks

THESIS  
Submitted to  
THE UNIVERSITY OF RAJASTHAN, JAIPUR  
for the award of the degree of  
DOCTOR OF PHILOSOPHY  
in  
EDUCATION  
October, 1980

Supervised by :  
Dr. N. VAIDYA  
Professor and Head  
Department of Education

Submitted by :  
TEG SINGH SANDHU

REGIONAL COLLEGE OF EDUCATION  
AJMER (RAJASTHAN)



# Certificate

Date

Oct. 15, 1930

Dr. H. Vaidya  
Professor and Head,  
Department of Education,  
Regional College of Education,  
Ajmer (Rajasthan)

I am pleased to certify that Mr. Jog Singh  
Tandhu has worked on the problem "Pastorinal  
Study of Adolescent Thought Using Piaget Type  
Tasks" under my supervision. This thesis is  
his original work and he is submitting it for  
the award of Ph.D. degree. It is further  
certified that no part of the work has been  
submitted for any degree earlier.

*Waidy*  
( H. VAIDYA )





## Acknowledgements

I owe first of all a sense of deep gratitude to my learned supervisor, Dr. N.Valiyya, Professor and Head of the Department of Education, Regional College of Education, Ajmer, for his worthy guidance regarding the present study. I feel very much grateful to him for the award of a research fellowship to work on an ERIC (NCERT) project under his supervision, which enabled me to carry out this study conveniently. I am also thankful to him for permitting me to use a part of the data collected.

I am very grateful to Dr. T.N.Mitra, Director, NCERT; Dr. B.N.Mukherjee, Director of Research, Council for Social Development; Dr. B.C.Das, Professor and Head of the Department of Teacher Education, NCERT; Dr. H.C.Hisra, Professor and Head of the Department of Measurement and Evaluation, NCERT; and Dr. R.N.Mehrotra, Principal, Central Institute of Education, New Delhi, for devoting their valuable time to discuss the frame-work of this study.

I am indebted to the Indian Council of Social Sciences Research, New Delhi for sanctioning a grant for computer analysis of the data. I am grateful to the Council for Social Development, New Delhi, for providing me all facilities for the analysis of the data. I am especially thankful to Mr. B.C.Nagi for taking personal interest in my investigations. I also owe my thanks to the Computronics India, New Delhi, for extending co-operation and the services of the Computer.



I should also thank Dr. J.K. Sood, Dr. G.H. Bhardwaj and Dr. I.M. Bahl who helped me a lot, not only in the execution of this study but also took keen interest in solving my personal problems during my stay at Regional College of Education, Ajmer.

My thanks are also due to the heads, teachers and students of all the schools who offered me their full co-operation in the process of data collection. Particularly, I would like to mention Mrs. Inderjit, Headmistress, Govt. Co-educational Model High School, Parso Nahna (Paridhot) for helping me to contact the various schools. I am thankful to Mr. Gian Singh and Mr. Rajinder Singh Mann for helping me in preparing the manuscript. Finally, I should like to thank Mr. N.K. Gupta for typing the manuscript with best accuracy and speed.

Teg Singh Sandhu  
( TEG SINGH SANDHU ) 15/10/80



## Table of Contents

Chapter		Pages
I	Some Background Issues Underlying the Problem	1 - 10
	Introduction	
	Thinking: A Multi-dimensional Activity	
	Philosophical Bases of Thinking	
	Philosophical Theories of Thinking	
	Psychological Bases of Thinking	
	Psychological Theories of Thinking	
	Solving the Problem	
II	Adolescent Thought as Viewed by Jean Piaget	10 - 31
	Introduction	
	The Stages of Cognitive Development in relation to the Characteristics of Concrete-Operational and Formal-Operational Thought	
III	Adolescent Thought : A Critical Review	32 - 50
	Introduction	
	Studies on Stages of Development	
	Studies Regarding the Relationship of Formal Thought with Age	
	Studies Related to Sex Differences	
	Studies on Relationship Between Formal Thought and Intelligence	
	Studies Regarding the Relationship Between Formal Thought and Culture	
	Studies on Academic Achievement, Personality and Adjustment in relation to Formal Thought	
	Concluding Statement	
	Status of Research on Adolescent Thought	
	Problems Posed in the Field	
	Distinguishing Characteristics of the Present Study	



**Section A****Framework of the Study****Introduction****Hypotheses****Sample****Data Collection Schedule****Statistical Treatment of the Data****Section B****Description of the Test  
of Piaget Type Tasks****Reliability and Validity of the Test  
of Piaget Type Tasks (Task-wise)****Reliability of the Test of Piaget  
Type Tasks (Combined)****Validity of the Test of Piaget  
Type Tasks (Combined)****Section C****Description of the  
Other Tests Used****Cattell's Culture Fair  
Intelligence Test (Scale 2)****Jalota's General Mental Ability Test****Dubey's Reasoning Ability Test****Anshana's Adjustment Inventory****Cattell's High School Personality  
Questionnaire (HSPPQ)****Space Relations Test (SRT)****Academic Achievement in School Subjects****Section A****Results of Descriptive  
Statistics**





## Section B

### Results of Bivariate Analysis

#### Interpretations and Discussion

VI	Analysis of Mathematical Structure Underlying the Adolescent Thought	125 - 130
----	---	-----------

- Introduction
- Some Background Studies
- The Present Study
- Correlation Matrix
- Obtaining the Factors
- Interpretation of Factors
- The Current Picture of the Structure  
of Adolescent Thought
- Concluding Statement

VII	Imp Effect Encountered : An Observation of Second Interest	150 - 163
-----	---	-----------

VIII	Summary and Conclusions	164 - 175
------	-------------------------	-----------

- Educational Implications
- Problems for Further Research

#### Bibliography

#### Appendices

- i) Test of Piaget Type Tasks (Part I)
- ii) Test of Piaget Type Tasks (Part II)
- iii) An Analogy Between Piagetian Grouping  
of Thought and Group Theory in Algebra
- iv) Code Sheet of Variables
- v) Imp Effect as Observed During  
Problem Solving
- vi) Original Data of Different Variables



## List of Tables

Table No.		Page
1.	Coefficients of Reliability and Validity of the Test of Piaget Type Tasks (Task-wise)	77
2.	Coefficient of Reliability of the Test of Piaget Type Tasks (Combined)	78
3.	Validity of the Test of Piaget Type Tasks (Combined) against Verbal Intelligence	80
4.	Validity of the Test of Piaget Type Tasks (Combined) against Non-verbal Intelligence	81
5.	Validity of the Test of Piaget Type Tasks (Combined against Reasoning Ability	82
6.	The Values of Mean, Median, Mode, Standard Deviation, Standard Error, Kurtosis and Skewness for Fourteen Dimensions of Personality (IPP)	89
7.	The Values of Mean, Median, Mode, Standard Deviation, Standard Error, Kurtosis and Skewness for Five Measures of Academic Achievement	91
8.	The Values of Mean, Median, Mode, Standard Deviation, Standard Error, Kurtosis and Skewness for the Measures of Adjustment, Verbal Intelligence, Non-verbal Intelligence, Space Relations and Reasoning Ability	92



9.	The Values of Mean, Median, Mode, Standard Deviation, Standard Error, Kurtosis and Skewness for the Ten Measures of Adolescent Thought	94
10.	F-ratios for the Analysis of Variance with respect to Five Age Levels and the Performance on Each of the Ten Piaget Type Tasks	97
11.	Mean Score and Standard Deviation of Each Task at Different Age Levels	99
12.	Results Regarding the Comparative Performance of Boys and Girls on the Task of Classification at the Five Age Levels as well as for the Combined Groups	103
13.	Results Regarding the Comparative Performance of Boys and Girls on the Task of Grouping of Thought at the Five Age Levels as well as for the Combined Groups	103
14.	Results Regarding the Comparative Performance of Boys and Girls on the Task of Generalization to Arithmetical and Algebraic Symbols at the Five Age Levels as well as for the Combined Groups	104
15.	Results Regarding the Comparative Performance of Boys and Girls on the Task of Permutations and Combinations at the Five Age Levels as well as for the Combined Groups	105



16.	Results Regarding the Comparative Performance of Boys and Girls on the Task of Ratio and Proportion at the Five Age Levels as well as for the Combined Groups	106
17.	Results Regarding the Comparative Performance of Boys and Girls on the Task of Probing Questions at the Five Age Levels as well as for the Combined Groups	107
18.	Results Regarding the Comparative Performance of Boys and Girls on the Task of Interpretation and Coordination of Information at the Five Age Levels as well as for the Combined Groups	108
19.	Results Regarding the Comparative Performance of Boys and Girls on the Task of Stating and Testing Hypotheses at the Five Age Levels as well as for the Combined Groups	109
20.	Results Regarding the Comparative Performance of Boys and Girls on the Task of Space Visualization at the Five Age Levels as well as for the Combined Groups	110
21.	Results Regarding the Comparative Performance of Boys and Girls on the Task of Grasping the Essence of the Problem at the Five Age Levels as well as for the Combined Groups	111
22.	Significant <sup>8</sup> t-Ratios Between the Performance of Boys and Girls on Ten Piaget Type Tasks at the Five Age Levels as well as for the Combined Groups	114





23.	Coefficients of Correlation Between the Performance on Piaget Type Tasks and the Other Variables	116
24.	Correlation Matrix Involving Ten Piaget Type Tasks	131
25.	Original Factor Matrix showing Factor Loadings of Piaget Type Tasks on the Significant Factor Extracted	132
26.	Correlation Matrix (34 x 34)	135
27.	Original Factor Matrix	137
28.	Varimax Rotated Factor Matrix	138
29.	Mean Scores and Standard Deviations on the Dimensions of Ratio and Proportion, Grasping the Essence of the Problem and Space Visualization at Different Age Levels	161



## List of Figures

Fig. No.		Page
1.	Twenty-nine Geometrical Figures Consisting of Triangles, Squares and Circles of Different Sizes, Colours and Shapes	59
2.	Hierarchical Classification of Students	63
3.	Beakers Containing Different Colourless Chemical Reagents	66
4.	The letter 'V' in Two Different Sizes	68
5.	A Board having Nine Squares Traced on It	71
6.	A Simple Pendulum	73
7.	Various Sets of Nine Dots	74
8.	Graphs showing Performance on Different Piaget Type Tests in Relation to Age During Formal-Operational Period	100
9.	Significant Factor Loadings of Different Variables on Original and Varimax Factor I	139
10.	Significant Factor Loadings of Different Variables on Original and Varimax Factor II	142
11.	Significant Factor Loadings of Different Variables on Original and Varimax Factor III	144
12.	Significant Factor Loadings of Different Variables on Original and Varimax Factor IV	145
13.	Significant Factor Loadings of Different Variables on Original and Varimax Factor V	147



14.	Significant Factor Loadings of Different Variables on Original and Varimax Factor VI	149
15.	Significant Factor Loadings of Different Variables on Original and Varimax Factor VII	150
16.	Significant Factor Loadings of Different Variables on Original and Varimax Factor VIII	152
17.	Lump Effect as Observed Regarding the Performance on the Task of Ratio and Proportion	162
18.	Lump Effect as Observed Regarding the Performance on the Task of Space Visualization	162
19.	Lump Effect as Observed Regarding the Performance on the Task of Grasping the Essence of the Problem	162



## CHAPTER - I

Some Background Issues  
Underlying the Problem





## CHAPTER I

### Some Background Issues Underlying the Problem

#### Introduction

Human thinking is very complex. Our present day scientific and literary culture is the product of this thinking. The investigation of the processes of thinking is very difficult, intriguing and mysterious. No doubt, thinking in general has been the subject of study of many philosophers and psychologists since long but it is only in this century that the experimental science began to interest itself in the processes and the structure of human thought. Piaget has studied the developmental aspect of human thinking starting from birth till late adolescence and has established an invariant sequence of four stages of development, i.e., the sensory-motor period (birth to 2 years), the pre-operational period (2 to 7 years), <sup>the</sup> concrete-operational period (7 to 11 years) and the formal-operational period (11 to 15 years). Though a good work has been done on the earlier stages of development, very few attempts have been made to investigate the adolescent thought, i.e., the formal-operational period and that too in a very narrow range.

Since the development of formal-operational thought is very important for the cognitive functioning of an individual throughout his life, and also it is most crucial from the educational point of view, the important issue before us today is to identify the structure of adolescent thought taking into



account the maximum number of its dimensions. Equally important is to develop a matching model of curriculum and pedagogy for class-room instruction in different subjects.

Before discussing in detail the Piagetian stages of development and their characteristics, let us have a general look on thinking and its philosophical and psychological bases.

### Thinking : A Multi-dimensional Activity

There are very few people who ever think about thinking. Those who have traditionally given descriptions of what a man does who thinks, have been the philosophers. They have chiefly relied on their own personal experience as their data. It is only recently that psychologists have tried to find out what happens when we think and what conditions influence our performance by applying the methods of science to this human capacity. Neither in philosophy nor in psychology have the results of this abstract entity been really successful in the past. But now a days, a general consensus has developed among the research workers and philosophers that thinking is much more complicated business than common-sense acquaintance with the term. According to the *Encyclopaedia Britannica* :

The term thinking itself has many definitions, no one of which is satisfactory to everyone. A useful one for those who attempt to study it scientifically defines thinking as that aspect of human (and animal ) activity that primarily involves processing of information ... The operations or processes involved in thinking are many and varied in kind and complexity. They include the simpler logical operations such as matching two items or substituting one for another,



and also many complex ones. They include the simpler mathematical operations such as addition and multiplication, and also more complex ones such as differentiation and integration. And they include many less logical processes. These processes are themselves the result of learning and hence vary from one thinker to another.

Thus thinking is a multi-dimensional activity with respect to both processes and products.

#### Philosophical Bases of Thinking

Thinking is an essentially human activity occurring in two basic forms. We may think in order to attain knowledge of what is, what must or what may be the case. We may also think with a view to making up our mind about what we will or what will not do. Following Aristotle, these two forms of thought may be called contemplation and deliberation respectively. Both forms may be carried on well or badly, successfully or unsuccessfully, intelligently or unintelligently. When contemplation is successful, it terminates in a conclusion and successful deliberation terminates in a decision or resolution. The form of reasoning involved in contemplation may be called theoretical and the form involved in deliberation may be called practical (Aune, 1967). The thoughts involved in both contemplation and deliberation have the following basic features:

- a) They are characteristically, but perhaps not necessarily, carried on in foro interno.



b) They are directed toward an object or a number of objects, and they either attribute something to, or deny something about this object or number of objects.

c) The language used to describe them is non-extensional in the sense of possessing at least one of the three intentional marks, i.e. :

i) Neither the sentence nor its negation implies either the existence or the non-existence of that thing to which the substantive expression truly applies.

Example : Ram is thinking about Ghosts.

ii) A non-compound sentence about thinking may contain a propositional clause in such a way that neither the sentence nor its negation implies either the truth or falsity of the propositional clause.

Example : It occurred to Mohan that earthquakes cause heart attack.

iii) Although things or events have many names and may be described in many different ways, the fact that a person thinks of them in connection with one name or description does not imply that he thinks of them in connection with some other name or description.

Example : Cohen thought that the author of Gita wrote Ramayana.

d) Thoughts are often conceived in relation to and are felicitously expressible by, specific verbal forms, i.e., they are often essentially linguistic or conceptual.

e) Particular thoughts have some kind of logical form; they may be categorical, hypothetical, disjunctive, universal, particular and the like.





When we investigate the processes of thinking, philosophically speaking, we must be aware of the features mentioned above regarding the construction of the test, i.e., how and to what extent can it possess these features.

### Philosophical Theories of Thinking

A survey of the full range of views on thinking that have been influential in the history of philosophy, could reveal that most important theories of thinking have been variants of one or more of the following basic views : Platonism, Aristotelism, Conceptualism, Imagism, Psychological Nominalism, Behaviourism, 'Ilyes' Approach and Analogy Theory.

#### Platonism

According to Platonism, thinking is either a dialogue in the soul involving mental words that refer to forms ( such as Redness, Triangularity, Flying, etc. ) and possibly to individuals (such as Socrates, etc. ) or a spiritual activity of inspecting or recollecting forms and discerning their nature and inter-relations.

#### Aristotelianism

According to Aristotelianism, thinking is an act of the intellect in which a thing's essence or intelligible form actually qualifies the intellect; to think about humanity is for one's intellect to be informed literally of the essence of humanity. For instance, humanity involves animality meaning



that one's intellect is also informed by the other essence, the latter being also the part of the former.

### Conceptualism

For the conceptualists, thinking is an activity of bringing concepts or ideas before the mind, these being either innate or else formed by abstraction from sense experiences and thus actually sharing the abstract features of those experiences

### Imagism

For the Imagists, thinking is basically a sequence of episodes involving images. These images are tied to certain "habits", which are the inveterate tendencies of the mind to move from one image to another. To think about triangularity, according to this view, is to imagine some particular triangle while disposed to pass on to other images of the same sort.

### Psychological Nominalism

According to the Psychological Nominalists, thinking is literally a dialogue in the soul (or better in the head) involving the use of verbal images or mental words which denote things or classes of things. In this view a complete thought is a mental utterance of a sentence, such as "Tom is tall".

### Behaviourism

According to Behaviourists, thinking is either thoughtful overt speech - thoughtful in the sense that it is in accordance with the various principles of relevance. Thinking is also defined by this school as evidence or inference that the agent



is prepared to cite in explanation of his behaviour - or a changing series of dispositions to behave intelligently that the agent can at any time avow.

### Ryle's Approach

According to Ryle, the idea that a non-habitual intelligent behaviour is always guided by silent thought, is mistaken. In his opinion, reference to interior and exterior acts of thinking is not in anyway needed for the explanation of most intelligent behaviour. The verbal behaviour may be regarded as intelligent, thoughtful, and even rational if it is done in accordance with certain principles of inference, evidence, relevance, etc. Therefore, purely overt calculation or deliberation is itself a process of thinking and that thinking is not something that is necessarily done silently in the soul. In other words, overt thinking is just as useful a mode of thinking as anyother, and there is no need, even no point, in always hunting for hidden acts of thought.

### Analogy Theory

Although Ryle's view of thinking does not, as a whole, succeed, it does come close to the truth. As all the calculation or deliberation that accounts for a man's actions is not done loud or on paper, so the reference to silent thought is constantly and legitimately made in order to account for activities that would otherwise remain inexplicable. According to Analogy Theory, a man may make a move in chess after sitting in silent anguish for long minutes at the board; and the



intelligence of this move will remain a stubborn question mark until perhaps after the game, he outlines the strategy behind it. Hyle has also argued that a man can learn to utter to himself as well as to utter out loud. While silent thought need not be inner speech, it may still be an activity that is at least formally analogous to speech. Thus while the thought of  $p$  is empirically different from the act of  $p$ , it may still be regarded as formally the same: both are activities that conform to the same principles and have many of the same implications. What is essential in both cases is that formally analogous activities are carried on in accordance with the same basic principles. This theory of thinking does more than merely correct the shortcomings of Hyle's view and it is perhaps the most satisfactory account of thinking yet developed by philosophers.

### Psychological Bases of Thinking

Psychologically speaking, thinking is defined operationally as the establishing of order(s) in the apprehended world. This ordering relates to objects as well as to representations of the world of objects, and the ordering of relations between the representations of objects. The figurative or pictorial representation (imagery) of what has been perceived makes it possible to order according to equality, similarity or difference. The objects with the same visual, acoustic, haptic or kinesthetic qualities are treated as belonging together, inequalities lead to separation from the grouping of similar objects. The action of ordering with figurative and





pictorial images is called intuitive thinking. Thought is said to be autistic if the ordering of the experienced world takes place according to states conditioned by feeling or motivation. Thought arbitrarily links persons, things or objects coinciding fortuitously with these inner states. If wish-fulfilment tendencies determine the results of thinking, the thought processes are defined as primary. On the other hand, when rational ordering techniques determine the results of thinking thought processes are defined as secondary. Magical thinking orders the relations of image, sign or symbol to the object as if objects as well as representations of them were capable of acting like human beings. This way of thinking is frequently found in younger children, uninformed adults and in exceptional existential states.

If the representations, thoughts, and their relations being ordered can no longer be expressed in imagery or figuratively, then thinking is non-intuitive, abstract or conceptual. In such thinking activity the task determines the direction that thinking will take. In the further course of socio-historical development it becomes possible to abstract from real actions, to replace them with mental actions, or those described with words (different signs are also used for this purpose). On this foundation the highest-abstract and generalized form of thinking arises. Simultaneously, a separation of cognition takes place and it becomes a special theoretical activity, which nevertheless remains linked to practice as the source and



criterion of accuracy, and the place where the results of thinking will be used.

It is only recently that psychologists have tried to find out what happens when we think and what conditions influence our performance by applying the methods of science to this human capacity. Though they are not fully successful in this venture, yet, they have shown that thinking is a much more complicated <sup>speaking,</sup> affair than common-sense acquaintance with it. Psychologically / thinking may be considered as an active purposeful process of cognition - a search for solutions to practical and subsequently to theoretical problems.

#### Psychological Theories of Thinking

In the psychological theory and research, the term 'thinking' has acquired a restricted meaning and has become identified with problem-solving. Thinking starts when we become confronted with some perplexity or problem. As long as things are going smoothly there is no necessity for thought. Dewey (1910) cites the homely example of a man progressing without difficulty along a road until he comes to a fork in it. The emphasis on thinking as problem-solving is very much in agreement with the psychological interpretations of it and also the theoretical traditions are equally committed to viewing thinking as problem-solving. For instance, the psychology of thinking based upon learning theory assumes that the same basic concepts of stimulus, response, discrimination and generalization are



applicable to problem-solving and that thinking is to be conceived as part of the process by which an organism adapts to its new environment. The greatest merit in this definition is that it relates the process of thinking to the behaviour of man coping with their environment which is what we call experimentation or learning. Thinking, in psychological literature, may be reviewed from the viewpoints of the five major schools of thought - Behaviourism, Gestalt, Functionalism, Psychoanalysis and the Geneva School. A brief introduction of these schools of thought has been given below:

#### Behaviourism

As a school of psychology, behaviourism is thought of as originating with Watson who announced the behaviourist position first in 1913 and thereafter became its vigorous spokesman. His other contemporaries were : Thorndike, Pavlov, Guthrie, Tolman and Hill. However, Skinner also joined the field later on. Most of them conceived themselves as biologists who happen to be interested in how organisms behave under various circumstances. They have preferred, usually, experimentation on animals and infants. Behaviourists have a conviction that a science of psychology must be based upon a study of that which is overtly observable. According to them, the behavioural event (thinking) begins with stimulation provided by the external world and ends with a response while the environment plays a part inbetween.



## Gestalt Theory

This school of thought developed in Germany with Prof. Max Wertheimer as its founder. Wolfgang Kohler and Kurt Koffka being the other associates of Wertheimer made the theory popular in America through their visits and books. Gestalters begin with abstract ideas, concerning the nature of perception, thinking and the structure of psychological experiences, and then they proceed to interpret familiar observations in terms of these novel concepts. Insight concept is one of the main contributions of the Gestalt school. There is a general agreement that insight occurs when there is integration of experience - a restructuring or seeing of a new relationship to the problem at hand.

## Functionalism

The idea of the programs of functionalism was first propounded by Titchener, who later on turned out to be an opponent of it. It put forward the concept of functional psychology according to which mind may be regarded as the collective name for a system of functions of the psychophysical organism. Later on many other psychologists became interested in the function of the mind as it is used in adaptation of the organism to its environment. University of Chicago (1900-1930) was the mainland where functionalism rose to its prominence. The psychologists primarily responsible for the growth included James Angell and Harvey Carr in addition to John Dewey. According to them, functionalism is a psychology of the adjustment of the organism to its environment. It is a cause-and-effect





psychology which is interested in how, why and what of mental operations. At the same time it studies the physiological substratum of mental events (thinking). John Dewey, saw the relevance of psychology to classroom teaching and learning. Later on functional psychologists like Francis Galton and James Cattell became interested in differential mental abilities, what they were good for, and how to measure them with mental tests.

### **Psychoanalysis**

The discussion on thinking would be incomplete without reference to Sigmund Freud as he has influenced the whole field of psychological thinking very widely. Though it will be difficult to state the postulates of thinking in the propositional form from the psychoanalytical viewpoint as the theory is too complex, however, the general standpoints can be discussed. Writers on psychoanalysis often stress that it is genetic as well as a dynamic theory, i.e., continuities in the life of the individual deriving from the past, leave their impact upon what is happening in the present. The theory suggests that a very young child is usually susceptible to influences which leave a permanent mark on his personality. According to the psychoanalytic theory, adult thinking either oscillates between or combines the two modes of thinking. The primary process thinking which is impulse-driven and largely irrational seeking immediate gratification at all costs even by hallucinations, and the secondary process thinking which is patient and logical willing to postpone gratification for the



future gains. The psychoanalytic theory has helped to erase the boundaries between the neurotic and the normal so that what was once relegated to as abnormal psychology has now become a part of general psychology. Finally, the genetic or the developmental aspects of psychoanalysis have brought to the fore the need for an adequate ego psychology.

#### The Geneva school

Jean Piaget and his collaborators in Geneva have produced abundant observations, both naturalistic and experimental, in support of his theory. Piaget chooses problems for investigation from the area of cognition without considering at the same time any other outside variable. He acknowledges his debt to Gestalt psychology in his thinking. Gestalt psychology is quite rich in ideas but Piaget goes a step further when he says that his schemas are more dynamic and modifiable structural units than the "gestalts". The schemas are characterized by mobility, transposability, generalizability, elasticity, self-modifiability to fit new data, built-in activity, and lastly they undergo evolution through corrective controls. According to Piaget, the inferior schemata slowly become superior ones and comparatively speaking more adequate to reality adaptation. In his theory, there is no place for insight because the complex schemata arise or evolve from the simpler ones already formed.

Through the use of his symbolic logic, Piaget has been able to point out the properties of thinking at various age levels in terms of the thinking operations of children within



an age group which they are capable or incapable of performing. Thus, as the child moves from middle childhood to adolescence his thought processes move from concrete operations to formal propositional thinking. The thought processes characterize the scientific method : considering all possibilities, making 'if-then' hypotheses subject to verification, organising the principles into some sort of network. It is worth mentioning here that language also plays a major part through permitting the child to represent action in thought. It does not produce the evolutionary stages of intelligence but is instead an agent in the service of intelligence.

The above mentioned discussion on thinking in its multi-variate aspects is of varying relevance to the researchers trained in different schools of thought. The starting thread of thought can be initiated in any context but the problem becomes uncontrollable when all the contexts are considered simultaneously. Secondly, it is beyond the reach of any single investigator to tackle this problem in all its aspects because of several intellectual complexities, scarcity of literature, paucity of tools and data and lastly, the physical limitations of time and other resources. Currently, the Geneva school has presented a fruitful model in which specific research on formal thought is badly needed. Consequently the problem has been posed as follows:

#### **Posing the Problem**

Now a days the major interest of psychologists and educationists is not only to understand individuals but also to



study the general trend of the development and structure of the human mind. The scientific investigation of thinking processes and of the structure of human mind is gaining importance because the growth of a highly logical mind has become one of the most important goals of educational instruction in the modern scientific society. The social scientists are expected to study the processes of thinking and its structure rationally as the physicists study the atom. At present whereas the products of thought in the form of our civilisation and culture are well known there is very little knowledge available about the underlying processes of thinking or about the very nature of thinking itself. In the contemporary usage the term thinking refers to a wide range of mental exercises, i.e., abstracting, analysing, knowing, opining, comparing, guessing, imagining, judging, reasoning, recalling, recognising, reflecting, remembering, searching for conclusions and understanding, etc. A late trend that has emerged in psychological literature considers thinking somewhat akin to problem solving (Valdya, 1976). A good work has been done on this approach by many research workers including Jean Piaget.

Jean Piaget has contributed immensely to the whole field of psychology in general, and to modes of human thinking particularly, over a period of 60 years or so. The important feature of Piaget's work is that he is more interested in studying the structure of developing human mind than its function and content. Piaget postulates the existence of cognitive structure which





like content and unlike function, does indeed change with age, and these developmental changes constitute the major object of study for him. According to him structures are the organizational properties of intelligence, created through functioning and invariable form of behavioural contents whose nature they determine.

As pointed out by Inhelder & Piaget (1958) "It is surprising that in spite of the large number of excellent works which have been published on the affective and social life of the adolescent so little work has appeared on the adolescent's thinking". No doubt thinking in general has been studied from the various standpoints, such as, Thematic thinking, Explanatory thinking, Productive thinking, Integrative thinking and Problem-solving thinking, etc., by many philosophers and psychologists like Dewey, 1910; Freud, 1949; Burt, 1940; Wertheimer, 1945; Rusphrey, 1951; Keats, 1955; Bruner et al, 1956; Russell, 1956; Bartlett, 1958; Mills and Bean, 1959; etc. Most of the investigations have been done developmentally. In the psychological literature there is a dearth of studies which could have analysed mathematically the content and form of the adolescent thought comprehensively.

The present study was designed to investigate the adolescent thought using the tests of Piaget Type Tasks and other variables, such as, intelligence (verbal and non-verbal), reasoning ability, space relations, academic achievement,



adjustment and other personality traits, and to analyse mathematically the contents of adolescent thought to identify the underlying structure of the same. It also attempted to find out, at the same time, the relationship between the measures of the dimensions of adolescent thought and the independent variables, i.e., age, sex, intelligence, reasoning ability, space relations, academic achievement, adjustment and personality traits.



CHAPTER II

Adolescent Thought as Viewed  
by Jean Piaget



## CHAPTER II

## Adolescent Thought as Viewed by Jean Piaget

## Introduction

Feeling that the approaches of philosophers to the problems of thinking were far too speculative and not sufficiently experimental, Piaget decided to spend four or five years for studying the development of logical thinking in the child. This interim study has turned out to be his life's work spanning a period of about sixty years. Piaget's work during this period has taken many forms and has been concerned with diverse problems but there is a remarkable continuity in his research which originates from his initial interest in problems of biology and the philosophy of knowledge, and constitutes a dialectic underlying all the theory and research. On the one hand there are the facts pertaining to man as a physical organism - the facts of biology and neurophysiology which indicate that man is equipped with a certain physio-chemical structure and that he must adapt to his environment in order to survive-while, on the other hand, are the constructions of man the thinker, i.e., the social and physical sciences themselves : logic, mathematics, social conventions and laws. The philosophical problem which arises from the confrontation of these two sets of data is : how do we formulate the relationship between human achievements, which include scientific laws and generalizations and those conditions which science asserts to determine our experience and behaviour? The research which Piaget has undertaken represents an attempt to answer this question (the question of the nature and





status of human knowledge ) by experiment and observation .  
 Piaget provides a larger content in which to view the acquisition of knowledge and competence as a consequence of growth and interaction with the physical and social environment. Piaget (1970a) notes that classical theories of development consider three aspects:

1. Biological maturation.
2. Experience with physical environment.
3. Experience with social environment.

He adds the fourth consideration also, while explaining his own viewpoint about the above three:

4. Equilibration.

The fourth consideration which makes Piaget differ from the classical theorists, needs further explanation.

#### Equilibration

Piaget believes that equilibration, if understood as he means it, is the fundamental factor in development, and necessary to coordinate the other three factors. Equilibration is a progressive, self-regulating process which leads step by step to a final state of reversibility that characterizes higher cognitive structures. It makes the child move from static configuration to the notion of a transformation, and once the child's thought includes the concept of a transformation he is prepared for the next stage. Piaget has described conservation also as an invariance in the midst of transformation which illustrates reversibility. Two additional concepts are needed in order to understand what Piaget means exactly by equilibration - these are



assimilation and accommodation. Assimilation is the first part of the two-part process of interaction between external reality and the child's own attained cognitive structure. Piaget uses the term assimilation for the process through which the new environmental experiences fit - in or become a part of the existing cognitive organization of the child. Accommodation is the second part of the process which deals with the change in the child's cognitive schema or structure so as to conform to the new external reality.

### The Stages of Cognitive Development

Piaget does not see the process of cognitive growth merely as a matter of continuous and quantitative improvements which remain qualitatively constant throughout the life span of human beings. He considers the qualitative changes in the underlying processes as a fundamental fact of mental growth. He has grouped these qualitative changes into a succession of four global stages. These stages satisfy a set of criteria of which the following are the most important : (a) qualitative change in cognitive contents, (b) a culturally universal invariant sequence in the overall progression of stages, (c) inclusion of the cognitive structures of each preceding stage in each subsequent stage, and (d) an overall integration of the structures of each stage. The description of the stages of development has been presented below :

1. The sensory-motor period (birth to 2 years)
2. The pre-operational period (2 to 7 years)
3. The concrete-operational period (7 to 11 years)
4. The formal-operational period (11 to 15 years).



# The Sensorimotor Period

It is the period of early development which begins with a stimulus for a few minutes, and ends when language and other symbolic ways of representing the world first appear. The primary information about this, however, is scattered over a number of Piaget's books and articles, yet major accounts are the empirical data regarding the sensorimotor period are available in the *International Review of Psychology* (1951, 1953 and 1954). The series was originally published in French between 1936 and 1943. The first book (1937) describes the development of initiation, play and conceptual evolution during the early years. The second book (1938) deals with the general characteristics of sensorimotor development. The third book (1954) is concerned with the child's intellectual grasp of space, time, causality and objects. Piaget has divided the overall developmental sequence of sensorimotor period into six stages. At the first stage (birth-1 month) the child shows little besides the reflexes with which he is provided at birth. At the second stage (1-4 months) the various reflex activities begin to undergo modifications with experience, and to inter-coordinate one experience with the other. At the third stage (4-8 months) the infant begins to perform actions oriented towards objects and events outside and beyond his own body. At the fourth stage (8-12 months) there is definite intentionality manifested by the means-ends or instrumental action sequences. Only familiar or habitual behaviour is involved. At the fifth stage (12-18 months) the child experiments to find new means,



and to pursue novelty for its own sake. At the sixth stage (18-24 months) the child begins to make internal and symbolic representations of sensory-motor problems and to invent solutions by implicit rather than explicit trial and error behaviour. Thus Piaget's sensory-motor stage is a step-by-step account of the infant's progress from cognitive contents that are reflexive, self-centred and disorganised to cognitive contents that are instrumental, adapted to the demands of the environment and well organized. The remarks of Piaget (1954) that 'intelligence organizes the world by organizing itself' demonstrate the phenomenon well. It is also worth noting as Bolton (1972) remarked that 'intelligence organizes itself by organizing the world.' Thus, it is the organization of the intelligence as well as of the world which takes place during the sensory-motor period.

### The Pre-operational Period

The child starts imitating the behaviour of the object at the sixth substage of sensory-motor period. These anterior imitations on the part of the child become internalized as 'images' - an image being a covert reproduction of an initially overt accommodation. In the pre-operational period, as the name implies, the internalization of actions has not reached the stage in which the child can make use of a system of operations. The development in this period can be conceived as preparing the way for this achievement through the increasing co-ordination of assimilation and accommodation in the child's symbolic activities. Piaget uses the word 'schemas' for the





imitative accommodation that is focussed on the outline properties of an object. Mostly, the child's thinking is dominated by his perception which gives rise to the limitations of the pre-operational thought. According to Piaget, the child at the pre-operational stage fails to conserve mass, weight, length, volume, etc. Thus, the child is not able to perform successfully on different invariance problems. Piaget has described that the pre-operational child reveals the lack of reversibility in his schemes when he fails on the invariance problems. The child does not realize that the operation can be reversed to restore the original equality. Also the pre-operational child has difficulties in understanding the effect of different points of view on the same event and in the integration of temporarily separate bits of information. Since the pre-operational period (2-7 years) is a long one in which many changes gradually occur, ~~wherefore~~ Piaget has divided this period into two parts :

- a) Ranging from 2 to 4 years.
- b) Ranging from 4 to 7 years.

At the sub-stage (a) the child fails to construct hierarchical arrangements because after a short while he forgets the defining properties. The sub-stage (b), i.e., the period from 4-7 years, has been labelled as the intuitive stage. During this period the child acquires a mode of dealing with many of the problems of integrating different viewpoints and information from



different sources. Even though the child can feel his way frequently to a correct answer through a problem but he still does not have a clear conceptual representation.

Thus, the pre-operational period marks the interval from the earliest beginnings of cognitive representations in the form of concrete imagery and rudimentary symbolic play to the time in which the child's conception of his environment and its operation is coherently organized.

#### The Concrete-operational Period

According to Piaget, children enter concrete-operational stage around the age of 7 years, on the average. The entry into this stage is the most decisive turning point in the entire course of cognitive development. The children's thinking who have attained the concrete-operational level bears a marked resemblance to the thinking of adults but the mental operations of this stage work only when they are being applied to information that the child has directly perceived. They do not work when they are being applied to information that is abstract and purely hypothetical. Since children belonging to this stage could deal only with concrete and tangible information it has been named as the concrete-operational period. Piaget believes that certain logico-mathematical structures make very good models of the actual organization and process of cognition during concrete-operational period. Thus, if Piaget says that the classificatory behaviour of the eight year old indicates that he possesses the grouping of logical class addition, he means that the child's thought organisation in the classificatory area has the properties of a Group, i.e., reversibility, identity,



associativity, composition, etc., which define this logico-algebraic structure.

Piaget (1967) claims that concrete mental operations can be grouped into two broad categories based on the kinds of information available in our environment : logico-arithmetic operations and spatial operations. Logico-arithmetic operations are contents that involve discontinuous information and spatial operations are contents that involve continuous information.

#### The Formal-Operational Period

The approximate age range for the onset of this stage, what we usually call adolescence, is roughly from 11 to 15 years. In most of the psychological theories of adolescence the major emphasis has always been on the emotional and social upheavals that occur during this period of life. Adolescence is usually portrayed as a period of trouble and turmoil (Ariesen, 1968). Adolescents are pictured as being in a state of constant and unrelieved conflict. They are said to be emotionally unstable and subject to bouts of depression. They are described to be torn between the desire to remain children and the need to assume the responsibilities of adulthood. Thus, the traditional view of adolescence is somewhat gloomy.

Piaget, in sharp contrast to the trouble and turmoil view, regards adolescence as the most exhilarating and productive time of life. According to him it is the time when one plans one's future and fixes the goals for life. Adolescence is a time of



great hopes and a time when simple answers to the burning questions are just not good enough. Piaget finds the thinking and reasoning of adolescents praiseworthy. He believes that intelligence reaches its peak between the age of 11 and 15 years. The thinking and reasoning during this period is clearly superior to that of childhood and it may even be superior to that of adulthood.

The reasoning at this stage is said to be hypothetico-deductive. Unlike the concrete operational thinking which operates on hard tangible facts, formal thought extends beyond the confines of everyday experience and is not tied up with perception and memory. The formal-operational thinking involves deducing conclusions from propositions which are hypothetical rather than facts actually verified by the adolescents. Piaget has drawn an important conclusion from the features of the hypothetico-deductive reasoning, i.e., the mental operations at the formal-operational stage may be expected from start to finish at a purely symbolic level. This suggests that intelligence has moved away from 'things' towards 'ideas.' Thus formal-operational intelligence transcends reality.

Language also plays a major role in hypothetico-deductive reasoning. Piaget believes that such reasoning would be impossible if the child is not able to pose questions verbally. This question-formulating ability is supposed to rest on a new mental representations of the formal thought which are no longer restricted to extrapolations from external reality.





Flavell (1963) has described formal thought as 'A generalised orientation, sometimes explicit and sometimes implicit, towards problem-solving : an orientation towards organising data (combinatorial analysis), towards isolation and control of variables, towards the hypothetical and towards logical justification and proof.' Brainerd ( 1978 ) has described the features of formal-operational thought as (a) it is hypothetico-deductive (b) it is scientific and (c) it is reflective-abstractive.

Thus the adolescents at formal-operational level can accept assumptions for the sake of argument. They make hypotheses in propositions and try to test them. They can go beyond the tangible. At the formal thought stage, children also become conscious of their own thinking, reflecting on it to provide logical justifications of their judgements. They develop an ability to deal with a wide variety of relations such as proportionality or correlation. Thus, a remarkable qualitative change in thinking takes place when children enter into formal-operational stage, from the concrete-operational period. A comparative analysis of the characteristics of concrete-operational thought and formal-operational thought has been presented below to make clear the process of change of the concrete structures available at the third stage into formal structures.



# An Analysis of the Characteristics of Concrete-operational and Formal-operational Thought

## Concrete-operational Thought

1. Classifications and serial ordering are employed in a step-by-step fashion, without relating all of the links into a system.
2. Well-mixed variables in an investigation cannot be separated.
3. Logical multiplication of factors is limited to one to one or two to two correspondence but a total  $n$  to  $n$  system is not yet available.
4. Reversibility in operations is limited to negation or reciprocity but they are not interrelated as a system.
5. Experimental variability is seen as a result of multiple causes and no systematic efforts are made to isolate and control factors or variables.

## Formal-operational Thought

1. Reasoning begins with propositions and hypotheses. A system of what is hypothetically possible is structured and followed by empirical verification.
2. Factors or variables in an experimental setting are seen as distinct and can be separated from one another.
3. A complete combinatorial system is available so that all combinations of factors ( $n$  to  $n$ ) can be exhaustively tested.
4. Reversibility is advanced by the inter-relationship of negation and reciprocity, resulting in the ability to maintain a dynamic equilibrium in a system involving many factors.

5. Variables can now be controlled systematically.



---

Concrete-operational  
Thought

---



---

Formal-operational  
Thought

---

- |  |   |
|--|---|
| 6. Chance or probability ideas are influenced by previous results, yielding a kind of gambler's fallacy.                 | 6. The notion of probability becomes operational and widely applicable.   |
| 7. The notion of correlations is incomplete and errors occur when anything other than simple relationships are involved. | 7. Correlations are no longer limited to 1 or 1/2 but are applicable, at least qualitatively, in such situations as 1/6, 2/7, 3/11 and so on. |
| 8. Proportions are not as yet available except in the simplest sense.  | 8. Proportions are now much more widely applicable in solving problems.   |
| 9. Experimental contradictions cannot be pursued in a systematic manner.   | 9. Because of the complete combinatorial system, experimental contradictions can now be isolated and solved.                                  |
| 10. Conservation is limited to those physical qualities that are easily tested.  | 10. Conservation is no longer limited to the immediate testable environment.  |
| 11. Thinking is a derivative of the child's own actions on concrete reality.   | 11. Coordination of reference systems is possible.  |
| 12. 'Models' represent the concrete reality that seems to be offered rather than abstract possibilities worked out.      | 12. In an experimental situation involving many variables, logical pairs are sorted out and tested.   |
|  | 13. The utilisation of a proof based on 'all other things being equal' is now pursued.  |
|  | 14. The binary system of propositional logic based on the operations of conjunction, disjunction and implication is operable.                 |
|  | 15. The IVT group transforms the binary system into a fully operational interconnected system.  |
-



To quote Piaget et al (1977), the Geneva school considers the following five characteristics as the *sine qua non* of the formal-operational stage :

1. The adolescent pupil should be in a position to state as well as test hypotheses. This type of reasoning is called the hypothetic-deductive one.
2. The adolescent pupil should be able to make the effective use of propositional logic.
3. The adolescent pupil should be in a position to separate form from content, and possibility rather than reality/<sup>should</sup>become, the chief distinguishing characteristic of his thought.
4. The adolescent pupil should be able to deal effectively with the entire combinatorial nature of operations, i.e., from the 16 binary combinations to 256 tertiary operations. It is a form of closed-unit system in which passing from one element of structure to another is always possible.
5. The adolescent should be in a position to generate all the possible cases which are derivable from one single identifiable mental structure, i.e., the INCO Group where the scripts have their usual meanings: I(identity), N(negation), R(reciprocity), and C(correlative or dual operation).

Jean Piaget (1972) has also hypothesized the existence of the fifth stage as well which he attributes to a aptitude variation, specialization and also commitment to a particular career.





JUN 19 1961 III

Adolescent Thought : A Critical  
Review



## CHAPTER III

## Adolescent Thought : A Critical Review

## Introduction

Most of the research conducted on Piaget's theory outside Geneva deals with cognitive contents belonging to the concrete-operational stage. It presents, journals that publish research on the psychological development of children receive more papers on the concrete-operational stage than on any other subject (Brainerd, 1970). There is a dearth of research studies on the formal-operational thought. In comparison to the number of excellent works published on affective, social and emotional domain of adolescents, little work has appeared in the psychological literature on the formal thought (Inhelder & Piaget, 1958). Whatever has been done, a majority of that has concentrated only on the determination of the various stages of development at which the different adolescents have been operating. Very few research studies have tried to find out the relationship of the development of formal thought to the other cognitive, cultural, social and personality traits of the adolescents. Still fewer have tried to analyse the formal thought mathematically to identify its structure comprehensively.

The studies belonging to the different areas are presented here in the tabular form for the sake of brevity and wholeness before working out their implications towards the rationale of the study at hand. They have been grouped, with respect to



the field and nature of different studies, into six categories comprising sections

- i) On stages of development.
- ii) Regarding the relationship of formal thought with age.
- iii) Related to sex differences.
- iv) On relationship between formal thought and intelligence.
- v) Regarding the relationship between formal thought and culture.
- vi) On academic achievement, personality and adjustment in relation to formal thought.

#### ✓ Studies on Stages of Development

Sr.	Name of the author(s) No. and year	Title of the study	Main Findings
1	2	3	4
1.	Chiappetta, L.F. and Colleste, L. (1973).	The Effectiveness of Verbal Label Training in Aiding Second Grade Pupils to Transfer Their Classificatory Skills.	Majority of the late adolescents and adults in United States of America function at con- crete-operational level.
2.	Jale, L.S. (1970).	The Growth of Systematic Think- ing : Application and Analysis of Piaget's First Chemical Experiment.	Majority of the adolescent subjects do not perform at formal-operations level.
3.	Gullit, L. (1972).	Adolescent Think- ing a La Piaget : The Formal Stage.	The adults, normal adolescents and gifted adolescents show varying amounts of formal thought. The percentage varies from 25 to 60.

Contd..



1	2	3	4
4.	Alkimi, S. (1963).	quantity concep- tions in college students.	Only 53% of the college students are clear about the conservation of volume concept. Thus they may be considered at concrete-operational level.
5.	Herrings, C. L. and Goffe, J. F. L. (1971).	Sensitivity of Formal Operational Thought.	Normal American adoles- cents do not reach the formal level of think- ing at the age of sixteen.
6.	Law, L. (1974).	Formal Operational Thought and the High School Science Curriculum.	Upper level secondary students, except a few able ones, do not reach at the formal-operational level.
7.	Jackson, T. (1966).	The Growth of Logical Thinking in Normal and sub- normal children.	Less than 50% of the 15 year old subjects attain a score representing formal-operations on the tasks presented to them.
8.	Joyce, E. K. (1972).	A Study of Formal Reasoning in ele- mentary education majors.	About 77% science teachers in elementary schools in the age group of 19 years and above are found operating at the formal level while about 8% are at the concrete level and the remaining 15% at the transitional level.
9.	Jurnacheck, A. A. (1975).	The Performance of Prospective Teachers on Certain Piaget- ian Tasks.	It has been found that 53% elementary school teachers operate at concrete-operational level and 43% at the formal-operational level.

Contd...





1	2	3	4
10. Piaget, J. et al. (1973)	Intellectual Development Beyond Elementary School IV Ratio: The Influence of Cognitive Style.	One-fifth of pupils during adolescence develop firm proportional reasoning.	
11. Piaget, J. and Inhelder, B. (1976).	Implication of Accumulating Data on Levels of Intellectual Development.	Over a very wide age range, 13-45 years, about one-third of the subjects attain formal level.	
12. Piaget, J. and Inhelder, B. (1976)	Intellectual Development Beyond Elementary School: Deductive Logic.	Less than fifty percent of the physics teachers use formal thought during problem solving.	
13. Keating, D.F. (1975).	Preocious Cognitive Development at the Level of Formal-Operations.	Majority of the adolescents fail to perform at formal-operational level.	
14. Kohlberg, L. and Gilligan, C. (1971).	The Adolescent as a Philosopher - The Discovery of the Self in a Post Conventional World.	All normal children attain the concrete-operational level during adolescence but most of them do not attain the formal-operational level.	
15. Lawson, J.E. and Blake, A.J. (1976).	Concrete and Formal Thinking Abilities in High School Biology Students as Measured by Three Separate Instruments.	It has been found that 47% of high school biology students operate at concrete-operational level and 53% at the formal-operational level.	

Contd.



1	2	3	4
16.	Lawson, L. L. and Renner, J. J. (1973).	Relationship of Science Subject Matter and Develop- mental Levels of Learners.	About two-third of the adolescent pupils fail to show formal thought in their mastery over the abstract concepts.
17.	Lawson, L. L. and Renner, J. J. (1974).	A quantitative analysis of respon- ses to Piagetian tasks and its impli- cations for curriculum.	About 22% of the college freshmen operate at formal-operational level while 51% and 27% are found at the concrete- operational and post- concrete-operational level respectively.
18.	Lee, L. C. (1971).	The Concomitant Development of Cog- nitive and Moral Modes of Thought : A Test of Selected Predictions of Piaget's Theory.	It has been found that less than 50% of the subjects operate at the final sub-stage of formal-operations.
19.	Lovell, T. and Suttorworth, J. W. (1966).	Abilities Underlying the Understanding of Proportionality.	A majority of the adolescent subjects do not perform at formal- operational level.
20.	Lovell, T. (1961).	A Follow-up Study of Inhelder and Piaget : The Growth of Logical Thinking.	Formal thought has not been attained by pupils of low academic ability even at fifteen years of age.
21.	McKinnon, J. J. and Renner, J. J. (1971).	Are Colleges Con- cerned with Inte- lectual Develop- ment?	About 50% of college freshmen operate at the concrete-operational level, 25% at the post- concrete stage and only 25% at the formal- operational level.

Contd..



1	2	3	4
+ 22. Mealinge, R.J. (1961).	Some Aspects of Problem Solving in Science.	Pupils of low academic ability even at fifteen years do not attain formal thought.	
X 23. Macke, G. and Macke, V. (1971).	The Development of Formal Thought as shown by Explana- tions of the Oscilla- tion of a Pendulum: A Replication Study.	Formal thought is confirmed as well as used to reject irrele- vant variables on simple pendulum prob- lem.	
X 24. Martirano, J.C. (1977).	A Developmental Ana- lysis of Performance on Piaget's Formal Operations Tasks.	Even the oldest age group (12th graders) does not consistently show formal-operational performance across all tasks.	
7 25. Nordland, et al. (1974).	A Study of Levels of Concrete and Formal Reasoning Ability in Junior and Senior High School Science Students.	About 86 % of the senior high school science students are at the concrete level while 14% are at the formal level.	
+ 26. Renner, J. L. and Stafford, B. G. (1973).	Teaching Science in the Secondary School.	Among the 300 students of grades ten, eleven and twelve about 66% are at the concrete level, 20% at the transitional stage and 14% at the formal-operational stage.	
X 27. Ross, R.J. (1973).	Some Empirical Parameters of Formal Thinking.	The Percentage of under- graduates operating at the formal level is above the 50% figure.	

Contd...



1	2	3	4
28. Cebibel, H. (1975).	Formal Operations in College Freshmen.	Among the college freshmen only 20% performs at the late formal level on all the three tasks used.	
29. Mondhyaya, G.A. (1970).	A Study of Intellect- tual Development and its Relationship with Intelligence and Achievement of 10th Grade Science Pupils.	Most of the pupils up to the age of 15 years do not attain formal level.	
30. Vaidya, H. (1964).	A Study of Problem Solving in Science Among Certain Groups of Adolescent Children.	Though adolescent pupils are in a position to state hypotheses, most of them are not in a position to test them. They do not exhaust all possibilities.	
31. Talwar, G.L. et al. (1970).	Written Pictorial Task Instrument: Its Development and Use.	Formal thinking develops little even upto the age of fifteen.	

#### Studies Regarding the Relationship of Formal Thought with Age.

1. Clayton, V. and Overton, E.P. (1976).	Concrete and Formal Thought Processes in Young (Adults) and Old Age.	Age related performance differences occur on formal-operational thought.
2. Annels, P. (1967).	A Study of the Deve- lopment in Logical Judgements in Science of Successful and Un- successful Problem Solvers in Grades Four Through Nine.	Formal thinking increases with age (J.A., H.A. and grade), it proceeds in stages which are depen- dent upon each other.

Contd...





1	2	3	4
3.	Inhelder, P. and Piaget, J. (1958). The Growth of Logical Thinking from Childhood to Adolescence.	As adolescence tends to approach adulthood, pupils are in a position to organize as well as mathematise their solutions.	
4.	Jangel, L. and Buell, J. (1972). Exclusion of Irrelevant Factors (The Pendulum Problem).	Formal thought increases gradually with age regardless of sex.	
5.	Linn, R. S. and Levine, J. P. (1976). Adolescent Reasoning: The development of the ability to Control Variables.	Elder adolescent pupils succeed to exclude variables even when different problems are used.	
6.	Portorano, J. (1977). A developmental analysis of Performance on Piaget's Formal Operations Tasks.	Mean scores on Piagetian tasks show an increasing trend with age.	
7.	Sayre, J. and Sanial, J. B. (1973). Piagetian Cognitive Development and Achievement in Science.	Formal thinking grows gradually during adolescence.	
8.	Shayer, M. and Dylan, J. (1978). The distribution of Piagetian Stages of Thinking in British Middle and Secondary School Children 14 to 16 Year Old.	There is no increase in proportion of pupils showing formal thinking beyond the age of 15 years.	
9.	Tonerville, J. C. (1974). The Pendulum Problem: Patterns of Performance Unifying Developmental Stages.	Over all level of performance on the pendulum problem is strongly related to age, but not to sex or to the school attended.	

(Contd. ...)



1	2	3	4
10. Vaidya, N. (1970).	The Growth of Logical Thinking in Science During Adolescence.	The mean performance on the various schemes of thought shows an increasing trend with grade.	
11. Walker, H.S. et al. (1970).	Written Piegation Task Instrument : Its Development and Use.	Formal-operations are independent of age between 18 to 37 years.	
12. Weeks, J. (1973).	The Relationship of Grade, Sex, Socio-economic Status, Scholastic Aptitude and School Achievement to Formal Operations Attainment in a Group of Junior High School Students.	The incompleteness of formal operations abilities at the ninth grade level indicates its subsequent growth still at higher age levels.	
13. Zanny, G.L. and Cox, J.L. (1975).	The Effects of Sex Differences on the Assessment of Formal Operational Thinking.	It has been found that ability to separate variables increases with age.	
14. Tudin, J.L. (1966).	Formal Thought in Adolescence as a Function of Intelligence.	Formal thinking increases with age.	

---

#### Studies Related To Sex Differences

---

1. Graybill, J.L. (1974).	A Study of Sex Differences in the Transition from Concrete to Formal Thinking Patterns.	It has been found that sex differences favouring boys begin to appear at the age of eleven.
------------------------------	---	---

Contd...



1	2	3	4
2.	Graybill, L.A. (1975).	Sex Differences in Problem Solving Ability.	Boys begin to score at formal level at 13 yrs. while girls lag-behind.
3.	Lawson, A.L. (1975).	Sex Differences in Concrete and Formal Reasoning Ability as Measured by Manipulative Tasks and Written Tasks.	Sex differences favouring males in formal reasoning are noticed.
4.	Rajput, H.D. (1975).	A Study of the Scheme of Proportion among certain Groups of Adolescent Pupils.	No significant sex differences exist on the scheme of proportion.
5.	Thayer, H. and Ryan, J. (1978).	The Distribution of Abstract Schemes of Thinking in Indian Middle and Secondary School Children 14 to 16 Year Old.	The simple pendulum problem shows no sex differences.
6.	Donerville, C.L. (1974).	The Pendulum Problems Patterns of Performance Defining Developmental Stages.	Formal thought hardly depends on sex and the type of schools.
7.	Weeks, J.E. (1973)	The Relationship of Grade, Sex, Socio-economic Status, Scholastic Aptitude and School Achievement to Formal Operations Attainment in a Group of Junior High School Students.	Significant sex differences are found on conservation of volume and other aspects.



# Studies on Relationship Between Formal Thought and Intelligence

1	2	3	4
1. Case, R., and Collinson, J.H. (1962).	The Development of Formal Thinking in Verbal Comprehension.	Children of matching CA and MA have different scores on formal thought. Since some other factors such as cultural back- ground, range of expe- rience and verbal reper- toire may be contributing to the development of formal thought.	
2. Clayton, V. and Overton, E.C. (1976).	Concrete and Formal Thought Processes in Young Adulthood and Old Age.	Except for the young sample, the operational tasks were found to be unrelated to fluid intelligence.	
3. Cloutier, R. and Goldschmid, H.B. (1976).	Individual Differ- ences in the Development of Formal Reasoning.	Significant correlations have been obtained between scores on the proportion test and non-verbal inte- lectual capacity as measured by the Raven's GM.	
4. Khan, D. (1976).	Relation of two Piagetian Stage Transitions of II.	A high correlation has been found between mental age and progression towards Piaget's stage of concrete-operations. However, the correlation is non-significant be- tween mental age and prog- ression towards Piaget's stage of formal-operations.	

Contd...





1	2	3	4
5. Vaidya, A. (1964).	A Study of Problem Solving in Science Among Certain Groups of Adolescent Children.	A given problem is solved over a wide IQ range.	
6. Stephens, J.L. et al.(1960).	The Development of Reasoning, Moral Judgment and Moral Conflict in Adolescents and Normals.	Significant correlations of WISC verbal IQ, performance IQ and Hull Scale IQ with Piagetian tasks of reasoning and formal operations have been reported for subjects 6 to 10 years.	
7. Valentine, J.L. (1973).	Performance on Two Reasoning Tests in Relation to Intelligence, Divergence and Interference Proneness.	The results show that convergent intelligence is a necessary but not a sufficient condition for success on the tasks.	

---

Studies Regarding the Relationship Between  
Formal Thought and Culture

---

1. Jaito, J.B. (1975).	A Study Comparing College Science Students' Performance on Piagetian Type Tasks, Including Cross-Cultural Comparisons.	No significant differences are found between cultural background and over all performance on Piaget type tasks among college science students.
2. Jomry, G.O. (1974).	The Effects of Culture and Education on the Acquisition of Formal Operational Thinking.	It has been found that a suburban culture background promoted the development of formal operations.

contd. next



Studies on Academic Achievement, Personality  
and Adjustment in Relation to Formal Thought.

1	2	3	4
1. Blasi, A. and Hooffel, J.D. (1974).	Adolescence and Formal Operations.	It has been concluded that personality develop- ment during adolescence may take place independ- ently of formal opera- tions.	
2. German, J.G. et al. (1976).	The personality of the child and the utilization of operative thought.	Significant correlations between different measures of operational thinking and different personality variables have been obtained.	
3. Tathway, J.L. (1975).	The Unique Contri- bution of Piagetian Measurement to Diag- nosis, Prognosis, and Research of Children's Mental Development.	It has been found that Piagetian factors are having a dominant con- current association with the measures of school achievement thus point- ing out the way to new and possibly more relia- ble and valid predictors of achievement.	
4. Osicki, K.J. (1973).	Affective and Cognitive Develop- ment: Comparison of Head Achievement and Risk Level with Pia- getian levels of Cog- nitive Development for Two Socio-eco- nomic Groups.	Cognitive development does not vary with either n.ach. or risk level.	
5. Sayre, B. and Daniel, J.B. (1975)	Piagetian Cognitive Development and Achievement in Science.	No significant relation- ship has been found be- tween the scholastic achievement and level of formal operations.	
6. Vaidya, N. (1979).	The Growth of Logical Thinking in Science During Adolescence.	The top group of success- ful problem solvers differs significantly from the bottom group in home adjustment, health adjustment and school adjustment.	



### Concluding Statement

Review of research studies presented on the preceding pages under the heading 'Studies on Stages of Development' shows that the percentages of adolescents (11 to 15 years) operating at formal-operational level vary on quite a wide range (approx. 15% to 60%) in different countries and cultures. There are some interesting studies in which it has been found that even the college students (above 15 years) and elementary as well as other learners operate in good numbers only at concrete-operational level. Though the studies reviewed do not cover the whole research conducted on this topic, yet if they are taken as a representative sample then the general trend emerges that the adolescents do not attain the level of formal thought upto the age of 15 years. That is why Piaget (1972) has started thinking about the existence of a fifth stage which may extend the period of growth to 20 years of age which was earlier considered upto 15 years of age. Thus, when it has been found that the adolescents do not operate fully at the formal level then it becomes very clear that they operate (mostly) at the semi-concrete and semi-formal operational level. Therefore, it becomes very necessary for a research worker, first of all, to determine the structure of this complex mode of thinking (adolescent thought) so that the effects of the different variables related to the nature of the determined factors of adolescent thought may be studied later on in depth as Royce



(1950) has pointed out that a proper order of research programmes might be ; first, to use a set of a priori measures in a field of investigation and factor analysis then to determine the basic traits or the other sources of variance operating; second, to study these factors, one at a time, by the technique of analysis of variance to determine how they are affected by the different experimental conditions or how they vary among groups that differ with respect to age, sex, education or the other pertinent background variables; and lastly, to study them experimentally in the laboratory for specific groups under carefully controlled conditions.

"The studies regarding the relationship of 'formal' thought with 'age' show that formal thought increases with age. To instead of taking a static picture at one age level, it seems more desirable to study formal thought at different age levels during the formal-operational stage (11 to 15 years). 'Studies Related to 'Sex Differences' are not unanimous in establishing whether sex differences exist or not with respect to the development of formal thought. Thus, it needs further verification. Similar is the position of the variables of intelligence, academic achievement, adjustment, personality and culture, etc.

#### Status of Research on Adolescent Thought

The remarks of Inhelder & Piaget (1958) regarding the status of research in the area of adolescent thinking are worth noting as they pointed out "It is surprising that inspite of the large number of excellent works which have been published on





the affective and social life of the adolescent - we hardly need remind the reader of the studies of Stanley Hall, Jaspars, Montousse, Pranger, Charlotte, Bühler, Lewis, Lavinia Lewis, Brodie, Fleming, or Debusse, or those by psychoanalysts such as Anna Freud and Helene Deutsch, and by sociologists and anthropologists such as Maclintock and Margaret Mead, not to mention others - so little work has appeared on the adolescent's thinking." Whatever scattered researches have been undertaken on adolescents in India and almost most of them have simply tried to identify the stages of development of the subjects under study. A few studies have attempted to investigate the relationship of the adolescent thought with the other outside variables. Still fewer could manage to determine the structure of the adolescent thought and that too only with respect to one or two dimensions of it. Perhaps, none has tried to analyse the comprehensive contents of the adolescent thought and its various dimensions to identify the global structure of adolescent thought.

In India the situation is still worse. Valiya (1975) reported : "It is a research desert characterized by the lack of personnel, problems and publicity". Some research workers have started grappling with the problems related to the adolescent thinking.

#### Problems Posed in the Field

Piaget and his co-workers have investigated the area of cognition without considering or giving much importance to the other variables like intelligence, personality traits, socio-



economic status, etc. It is very necessary to explore the area further with respect to as many independent variables as possible. It does not mean that the past adventures on thinking have all been fruitless since on their basis we have known the road yet to travel.

"Till today very little is known on thinking in relation to the past history of the individual. Thus, 'what makes people attack problems' according to Cohen (1964) may contribute to our understanding of thinking processes. Vincke (1962) has mentioned that the whole area awaits invasion through case study approach with a view to collect as well as to interrelate as many aspects of performance as possible in as many situations as practicable. Duncan, Wheeler, Biel, Trowers and Watson have also emphasized the importance of investigating thinking in relation to some outside variables like intelligence, personality traits, socio-economic status, motivation, ego involvement, etc. (Vaidya, 1975). The stage concept propounded by Piaget also needs to be investigated in depth alongwith the emergence of various mental operations at various age levels. Lovell (1973) while carrying out several studies on developmental processes in thought among children varying widely in age, intelligence and culture, has suggested the following problems which cry for solutions

1. What is the role of experience (physical and mathematical) in intellectual development of children? How is it to be handled?



2. What 'Bad Start' School in U.S.A., what is the long term influence or impact of early stimulation on the culturally deprived and on certain types of school educable retarded children?
3. What is the effect of variables like emotional life, teaching learning techniques based on Piaget's works, culture and sub-culture patterns and the restricted functioning of any schema within a given area of knowledge at one time on cognitive growth?

There are several difficulties which need to be tackled or mastered before we can understand clearly the nature of thinking : problem solving, concept development and attainment. The major difficulty lies in our failure to understand the sequence of reasoning from the very early childhood to late adolescence, not only within each age-group but also across the various age groups over a very wide range. Precisely speaking, the field of human thinking as a whole poses many fundamental problems which are yet to be investigated, even partially, before we can fully understand it. The most crucial problem of human thought, more accurately adolescent thought, is the understanding, identification and determination of its underlying mathematical structure which the present study has attempted to tackle.

#### Distinguishing Characteristics of the Present Study

This study takes its inspiration from the Geneva school. Jean Piaget, being its leading advocate, has contri-



buted to the whole field of psychology immensely for the last sixty years or so. The present study has some distinguishing characteristics over the studies of Piagetian context as follows:

1. It attempts to psychometrize the test of Piaget Type Tasks, which can be administered in the group setting.
2. It draws a large size of sample for obtaining meaningful results.
3. It includes a large number of outside variables with a view to investigate the phenomenon in depth.
4. It subjects data, so collected, to a highly mathematical technique - factor analysis - rarely used by the earlier research workers.
5. The tasks, included in the test of Piaget Type Tasks, involve a continuous chain of reasoning.





CHAPTER IV

Plan and procedure



## CHAPTER IV

### Plan and Procedure

#### Section A

#### Frame Work of the Study

##### Introduction

As stated earlier this study was undertaken to determine the mathematical competence of adolescent thought (described in Chapter II) through factor analysis. The usual technique of factor analysis starts with a correlation matrix of a set of variables which is reduced to comparatively very small number of factors to explain the underlying nature and behaviour of the variables. On the basis of the results obtained through factor analysis a theory or a mathematical model can be formulated and vice versa, i.e., a model or a theory if postulated beforehand is verified. It was in line with the former approach that the study was launched to identify a mathematical model of adolescent thought. In addition to this, it was intended to seek evidence regarding the relationship of some independent variables such as age, sex, intelligence, reasoning ability, space relations, academic achievement, adjustment and other personality traits with the different dimensions of adolescent thought measured by the Piaget Type Tasks. Specifically speaking, the investigation was guided by the objectives given below:



- a) To develop a reliable and valid paper-pencil test of Piaget "type" tasks to provide data regarding the various dimensions of adolescent thought.
- b) To determine the relationship between the performance on Piaget "type" tasks and the independent measures of measures of intelligence, reasoning ability, space relations, academic achievement, adjustment and other personality traits (H<sub>1</sub>).
- c) To find out the effect of age and sex on the performance on Piaget "type" tasks.
- d) To identify the factorial structure of adolescent thought.

#### Hypotheses

The following hypotheses were proposed to be tested through this study:

1. Does the performance on Piaget "type" tasks increase with age during the formal-operational period?
2. Whether boys and girls perform equally well on Piaget "type" tasks?
3. The measures of intelligence, both verbal and non-verbal, correlate significantly with the measures of the dimensions of adolescent thought.
4. There exists a significant relationship between the measures of academic achievement and the measures of the dimensions of adolescent thought.
5. The measures of reasoning ability and space relations yield a significant correlation with the various measures of adolescent thought.



6. The measure of adjustment is significantly related to the performance on Piaget "type" tasks.
7. The measures of personality (15%) exhibit significant relationship with the measures of the dimensions of adolescent thought.
8. The performances on Piaget "type" tasks form an inter-related measure of adolescent thought and exhibit a unifactor structure.
9. The measures of intelligence, academic achievement, reasoning ability, space relations, adjustment and personality cluster in specific constellations with the measures of dimensions of adolescent thought explaining thereby the common factor variance.

#### Sample

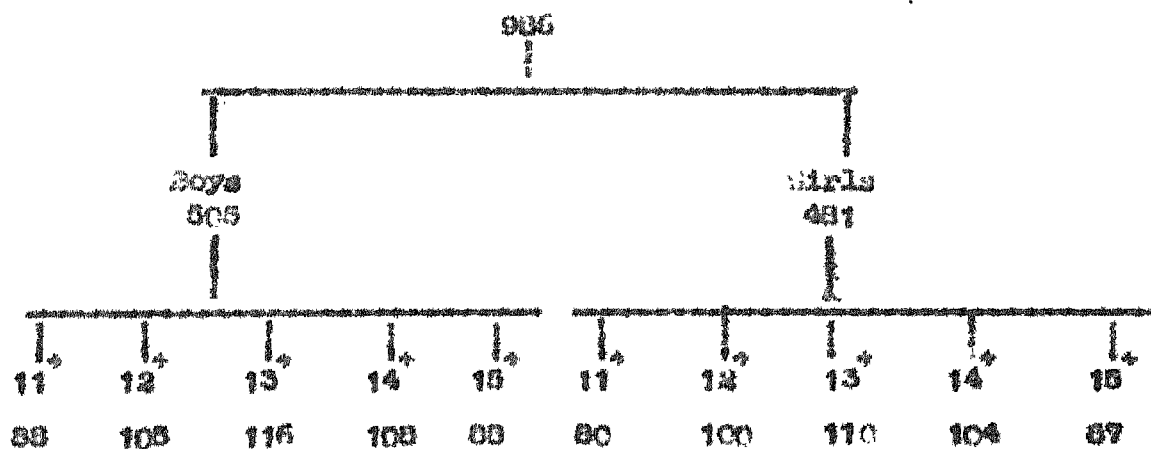
The sample for the study was drawn among the students of twelve high schools situated in the rural areas of Multan and Faisalot districts of Punjab and administered by the Department of Education, Govt. of Punjab. A purely rural sample was taken, first, to avoid heterogeneity which would have been caused by pooling together the urban and rural samples as the research findings (Jocilia, 1973) show. Second, the schools in the rural areas of Punjab are having a homogeneous population of students as they possess a similar socio-cultural background. Third, the academic atmosphere and the schooling facilities provided by the government schools in the rural areas are almost identical. It may be recalled that the study was planned to determine the mathematical structure of formal thought. The expected age range for the development of formal thought is 11 to 15 years.





To draw a representative and homogeneous sample of 11 to 15 year old students (numbering about 3000) studying in the above mentioned twelve high schools, the dates of birth of all the students were noted down. And to control age and grade simultaneously only the students at 11<sup>+</sup>, 12<sup>+</sup>, 13<sup>+</sup>, 14<sup>+</sup> and 15<sup>+</sup> year age levels and studying in VI, VII, VIII, LI and LI grades respectively were picked up. Then a random sample of about 100 students was drawn from each school, taking almost equal number of boys and girls, from each grade. The final sample consisted of 986 students (505 boys and 481 girls) who appeared in all the tests and whose other records were also complete. The frame of the final sample was as given below:

#### Total sample



#### Data Collection Schedule

It took three days to take data on a group of 80 students from <sup>a</sup> school. On the first day the classwise lists of the students studying in the school were taken. The dates of birth



were noted down to draw a representative sample from each age or grade level. The academic achievement scores of the students included in the sample were taken for the five school subjects, i.e., Mathematics, Science, English, Punjabi and Hindi. Four tests were administered on the second day -- Thurstone's Adjustment Inventory and Cattell's IPI in the morning session and Binet Type Tests (Part I) and Cattell's Culture Fair Intelligence Test in the evening session. Again four tests were administered on the third day. Binet Type Test (Part II) and Jolota's GVI in the morning session and Space Relations (GVI) and Abbey's Reasoning Ability Test in the evening session. Thus it took 6 complete days to gather data on the sample of one school. In all, data were collected from twelve schools. The school teachers' help was of immense importance in the process of administration of tests and procuring of records such as dates of birth and academic achievement scores, otherwise, the task would have been very cumbersome for the investigator to accomplish.

#### Statistical Treatment of the Data

There are two major schools of thought regarding the operational aspect of factor analysis. The first may be named as the British school in which reference could be made to the works of Spearman, Burt, Brown, Thomson, Stephenson, Allouney, Ayscock, Abzinger, Brown, Cattell and Vernon. They advocate Hierarchical Group Factor Theory. The second is the American school of thought where the works of Thurstone, Kelley, Paterson and Elliot, Alexander and Guilford are worth noting. They believe in Multiple Factor Theory. According to the first school



of thought "all branches of intellectual activity have in common one fundamental function ( or group of functions) whereas the remaining or specific elements of the activity are seen in every case to be wholly different from that in all others." The second school of thought postulates that the cognitive functions are based on "a number of" components of more nearly equal variance" the multiple factors. Though both the schools have their own specifications regarding the interpretations of the common variances operating among the different tests of cognitive abilities, yet they convey the same sort of information with a little variation in the language used for explanations. Blasinger and Herman (1933) and Jensen (1939) demonstrated quite early that the contents of group factors correspond very closely to that of multiple factors. This study took inspiration from the first school of thought, hence, the technique chosen for factor analysis was that of Principal Axis Method.

The data regarding the 34 measures were put into 34 x 34 correlation matrix and subjected to factor analysis to determine the factorial structure of adolescent thought. The computations were carried out through "ELIAC - 1032 Computer" at Computronics India, New Delhi using "A-1 programs for factor analysis given in Statistical Package for the Social Sciences (SPSS) by Nie, et al. (1970). One-way analysis of variance technique was used to determine the age and sex differences regarding the performance on Piaget Type Tasks at different age levels. The relationships between the measures of the dimensions of adolescent thought and the measures of the independent variables,



namely, intelligence, reasoning ability, space relations, academic achievement, adjustment and personality were worked out through bivariate analysis. The descriptive statistics were also computed to know the distributions of the various measures included in the study.

### Section B

#### Description of the Test of Piaget Type Tasks

Being a factor analytical study which requires a sufficiently large sample, particularly, when the number of variables handled is large, the data were to be collected in group settings. A paper-pencil test for group administration, consisting of Piaget Type Tasks, was developed by the investigator which in the final form consisted of ten tasks - five each in Part I and Part II.\* These tasks were the simplified forms of the ones already used by various research workers as an interview technique or for the individual administration in different investigations of formal thought. The following dimensions of adolescent thought were covered by these tasks

#### Part I

Task No.	Dimension of Adolescent Thought Covered
1	Classification
2	Grouping of Thought
3	Application to Arithmetical and Spatial Problems.

---

\* See appendices (i) and (ii)





<u>Task No.</u>	<u>Dimension of Adolescent Thought Covered</u>
4	Permutations and Combinations
5	Ratio and Proportion

## Part II

6	Formulation of Probing Questions
7	Interpretation and Coordination of Information
8	Stating and Testing Hypotheses
9	Space Visualization
10	Grasping the Essence of the Problem

The objective of each task alongwith the detailed description and mode of administration have been presented below:

### TASK NO. 1

#### Objective

The task was designed to serve as a measure of classificatory ability. The purpose of the task was to find out if the subjects can work out a criterion on the basis of the common properties of the objects for their classification. Both primary as well as secondary classification abilities are expected to be developed at the formal-operational stage.

#### Description

This task consisted of 27 geometrical figures which could be classified into three categories with respect to shape (9 circles, 9 triangles and 9 rectangles) or size (9 small, 9 medium and 9 large) or colour (9 white, 9 shaded and 9 crossed). In every case, each category could be further subjected to







secondary classification making three sub-categories on any two of the three criteria (shape, size and colour) leaving aside the one on which the primary classification has been done.

The figures were printed on a sheet of paper, keeping in view the maximum possible combinations of different figures with respect to the classificatory criteria (shape, size and colour) so that the subjects have to make equal efforts to classify the figures on any of the criteria mentioned above. The subjects were asked to do first primary classification and then secondary classification selecting a criterion of their choice in each case. It was for the subjects to identify the criteria mentioned earlier. Scoring was done awarding one score for each correctly classified figure. The maximum score on this task could be 54 and the minimum as zero.

#### Administration

A gardener gave a bunch of flowers of different types to his son and asked him to classify the flowers into different groups. The boy put the roses in one group, the chameli in the other and so on. Then the gardener asked him to further sub-classify the roses into different categories. The boy put the red roses in one category, the white roses in the other and so on. Now you go through the task given ahead and try to perform as demanded.

Here are given some geometrical figures on the opposite page (Fig.1). Each figure has been assigned a number for its identification. Classify these figures into three main categories in such a way that similar figures come under one category.



You are to write only the numbers of the figures under the categories, I, II and III to which they belong.

Category I

Category II

Category III

Now, further sub-classify each category into three sub-categories in such a way that similar figures of each category come under the three sub-categories of the same.

Category I  
Sub-categories  
A      B      C

Category II  
Sub-categories  
A      B      C

Category III  
Sub-categories  
A      B      C

### TABLE NO. 2

#### Objective

The task was meant for the determination of the development of various postulates of grouping of thought; such as, closure, associativity, identity, inverse and tautology\*. The combination of the development of all these postulates has been referred to as the measure of grouping of thought.

#### Description

In this task a classification hierarchy printed on a paper was provided to the subjects. The classification hierarchy

\* For further details see appendix (iii)

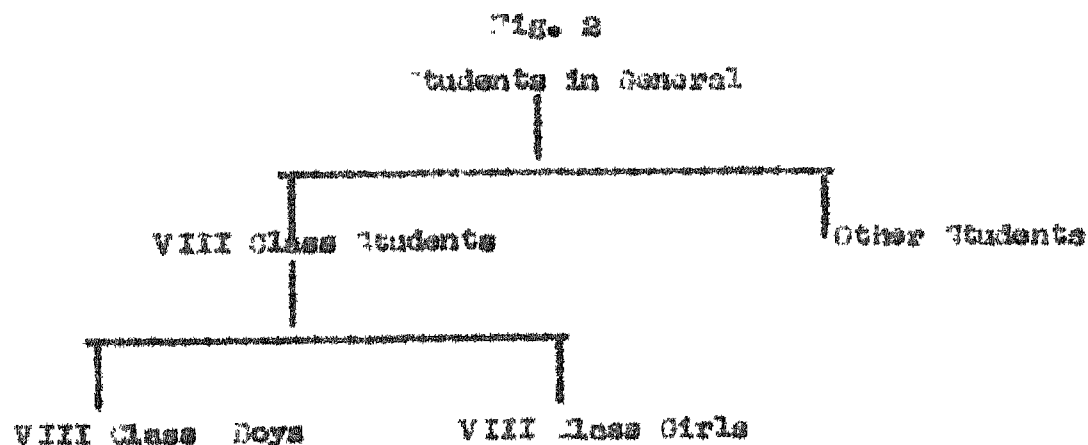




showed that the students in general had been classified into two categories, i.e., VIII class students and other students and then VIII class students were further classified into two categories of VIII class boys and VIII class girls. The subjects were asked to answer seven questions framed regarding the five postulates of the grouping of thought, i.e., closure, associativity, identity, inverse and tautology. One score was awarded for each correct answer, thus, making the maximum score on this task to be 7 and the minimum to be zero.

#### Administration

Look through the classification hierarchy given below in Fig. 2 and with the understanding of it answer the questions given above.



1. If VIII class boys and VIII class girls are grouped together, what name will you give to the group formed?
2. If VIII class boys are grouped with VIII class students and then both in combination are grouped with students in general, what name will you give to the group formed?



3. If VIII class students are grouped with students in general and then both in combination are grouped with VIII class boys, what name will you give to the group formed?
4. If VIII class boys are grouped with a class without students what name will you give to the group formed?
5. If VIII class boys are grouped with VIII class girls and then VIII class boys are taken out from the group, what name will you give to the group left behind?
6. If VIII class boys are grouped with VIII class boys, what name will you give to the group formed?
7. If VIII class boys are grouped with VIII class students, what name will you give to the group formed?

### PART NO. 3

#### Objective

The assessment of the ability to generalize was the purpose of this task. Generalization of both the arithmetical and algebraic series with respect to the operations of addition, subtraction and multiplication had been taken into account. The overall score represented the measure of generalization to arithmetical and algebraic symbols.

#### Description

This task consisted of three series of numbers based on the mathematical operations of addition, subtraction and multiplication in the beginning and later on they were symbolized



to algebraic series under the same mathematical operations as mentioned above. Some spaces were left blank towards the end of arithmetical as well as algebraic series so that the subjects may understand and internalize the logic behind the formulation of these series in the beginning and then on the basis of the generalization they may fill in the blank spaces. The scoring was done allotting one score for each correct entry in the blank spaces. The maximum score on this task may go upto 30 and the minimum to zero.

#### Administration

Three sets of numbers and algebraic symbols having two columns each are given below. In each set you will find some relationship between the entities of the two columns. Try to understand the relationship and fill in the blanks given in each set.

1	2	3
2	5	-7
6	9	-13
10	13	-19
14	(.....)	-25
(.....)	(.....)	(.....)
5 x 2	=	10
5 x 3	=	15
5 x ( ... )	=	20
(....) x 5	=	25
(....) x (....)	=	(.....)
1	1+3	-1
1 + 4	1+7	-1+6
1 + 8	(.....)	-1+12
(.....)	(.....)	(.....)
5 x 1	=	5
5 x (1 + 1)	=	5(1 + 1)
5 x (1 + 2)	=	(.....)
(.....) x (.....)	=	(.....)
(.....)	3	(.....)
(.....)	(.....)	(.....)
5 x (.....)	=	3
(....) x (....)	=	(.....)



## PART IV. 4

## Objective

The task was designed to assess the ability of the subjects to make the various permutations and combinations of the given materials and the operations. Thus, the performance on the task was taken as the measure of the ability to make permutations and combination.

## Description

The task consisted of four beakers (1, 2, 3 and 4) containing colourless chemicals and a fifth beaker (5) which contained an indicator but that too colourless. There was another empty beaker (6). The subjects were to make the imaginative permutations and combinations as all the above beakers were presented to the subjects just as diagrams on the paper.

The problem was posed as that a student while experimenting with these chemicals suddenly got a yellow colour when he mixed some of the chemicals from the beakers 1, 2, 3 and then put the small quantity from the beaker 5. What possible tries (permutations and combinations) they could make to get the same colour again. Thus the subjects could make the combinations taking one, two, three and four beakers at a time. One score was awarded for each un-repeated correct combination. The highest score on this task could be 13 excluding examples and the minimum being zero.

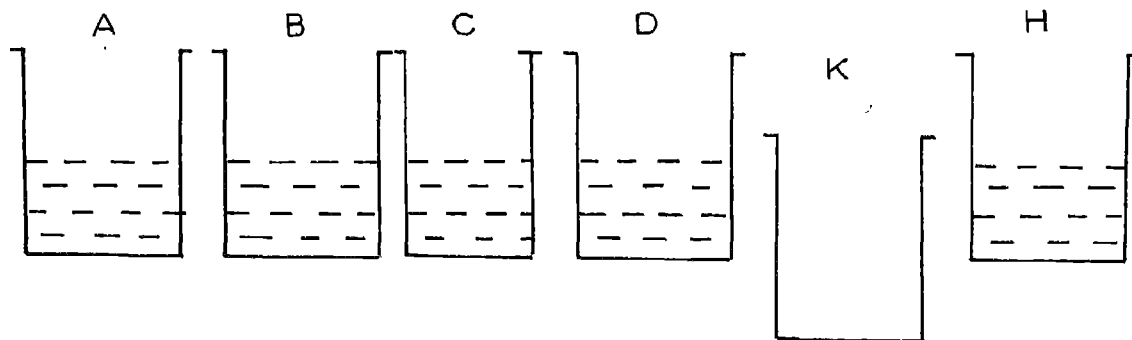




### Administration

Four beakers A, B, C and D are placed on a table (Fig. 3). The fifth beaker E is also placed a bit away. All the beakers are filled up with different colourless chemical reagents. There is one empty beaker K. Ann performed an experiment with these chemicals one day. He took out the chemical reagent from some of the A, B, C and D beakers and put into the beaker K. Then he took out the reagent from beaker E and put it also into the beaker K. Thus, the contents of the beaker K became yellow in colour. What experiments will you perform to find out the reagents which on putting together had made the yellow colour appear? Describe all possible experiments.

Fig. 3



### Examples:

Experiment No. 1 Took out the chemical reagent from the beaker A and put it into the empty beaker K. Then took out the chemical reagent from the beaker E and put it also into the beaker K.

Experiment No. 2 Took out the chemical reagents from the beakers B and C and put them into the empty beaker K. Then took out the chemical reagent from the beaker E and put it also into the beaker K.

Similarly, you write down the other possible experiments.



## TABLE 5

## Objective

The objective of the task was to assess the development of the concept of ratio and proportion among the adolescents. The simple whole number ratio and the complex ratio operations had been dealt with to get the measure of the ratio and proportion.

## Description

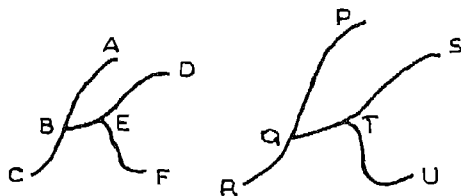
A letter 'K' in two different sizes was printed on a paper. The dimensions of the small size and the large size of the letter were in the ratio of 2:3. The lengths of the arms of the small size letter were given and the students were to find out the corresponding lengths of the arms of the large size letter. One score was awarded for each correct answer where the lengths of the arms were the simple multiples of the given ratio and two scores for each correct answer were awarded where complex ratio operations were involved. The maximum score on this task could be 7 and the minimum as zero.

## Administration

A letter 'K' is given below (Fig. 4) in two different sizes - one small and the other large. It is given that the lengths of the arms of the small letter and the large letters are in the ratio of 2:3. On the basis of this information answer the questions given below:



Fig. 4



1. If length of the arm  $EL$  is 4 cms., what will be the length of the arm  $ET$ ?
2. If length of the arm  $EP$  is 8 cms., what will be the length of the arm  $ET$ ?
3. If length of the arm  $ET$  is 16 cms., what will be the length of the arm  $ET$ ?
4. If length of the arm  $ET$  is 10 cms., what will be the length of the arm  $ET$ ?
5. If length of the arm  $ET$  is 9 cms., what will be the length of the arm  $ET$ ?

## TASK NO. 6

## Objective

The purpose of the task was to determine the extent of the development of the ability to formulate probing questions about any object or its functioning which is a basic characteristic of the formal thought. The over-all performance was designated as the measure of the formulation of probing questions.

## Description

The task was meant for obtaining the measure of the ability to formulate probing questions. The subjects were to



ask questions quite novel in nature, about the bicycle and the cow, whose answers were beyond their comprehension. Thus the subjects were to probe into, imaginatively, all types of situations wherever they find something un-understandable or unknown about the above mentioned objects. It was an open ended task. One score was awarded for each correct (meaningful) question posed. The maximum score obtained on this task was 21 and the minimum was zero.

#### Administration

The students of your age are very curious to know about the things in their environment. Number of questions come to their minds whose answers they do not know. For example, Mohan, a student of your age asked the following questions about the sun:

1. Is the sun a ball of fire in reality?
2. Why the sun does not fall on the earth?
3. Can we live without the sun?
4. What is the temperature of the sun?

Thus many questions might have been coming to your mind also.

You please write down as many questions as you can, whose answers you do not know, about (a) Bicycle and (b) Cow.

(a) Bicycle

(b) Cow





## TABLE No. 7

## Objective

The task was designed to assess the ability to interpret and coordinate a given information. Thus, the performance on the task represents the measure of the ability of interpretation and coordination of a given information.

## Description

This task consisted of a board having nine squares printed on a paper. The subjects were informed that first these squares were painted row-wise with blue, white and red colours respectively and then these squares were painted column-wise with red, blue and white colours respectively. This new colours emerged on those squares which got paints of two different colours and the others remained of the same colour which got the paints of the same colour twice. The subjects were to interpret and coordinate the information to find out the colours of which the different squares appear, when both the painting strategies were over. Scoring was done awarding one score for each correct answer. The maximum score on this task could be 9 and the minimum as zero.

## Administration

Here is given a board having traced nine squares upon it (Fig. 5). The top three squares (A,B,C) were painted blue, the middle three squares (D,E,F) were painted white and the bottom three squares (G,H,I) were painted red. When they were painted second time it so happened that the left three squares (A,D,G) got painted red, the middle three squares (B,E,H) got



painted blue and the right three squares (4, 5, 6) got painted white. Thus the different colours got mixed and changed in the various squares as follows:

1. The square which was painted blue and red or vice versa looked grey in colour.
2. The square which was painted blue and white or vice versa looked light blue in colour.
3. The square which was painted red and white or vice versa looked pink in colour.

Thus, the squares on the board appeared to be of different colours. You write down the name of the colour of each square in it.

Fig. 5

A	B	C
D	E	F
G	H	I

TASK NO. 8

### Objective

The objective of the task was to determine the extent of the development of the ability to state and test hypotheses.



However, two different measures could be taken for stating hypotheses and testing hypotheses, but here the combination of the both has been taken as the measure of the ability to state and test hypotheses.

### Description

The task was based on a simple pendulum, the diagram of which was provided to the subjects in the printed form. The subjects were to state hypotheses regarding the factors upon which depends the time period (time taken for one oscillation) of the pendulum. Then they were to test these hypotheses describing the controlled experiments. This was an open-ended task. Scoring was done awarding one score for each correct statement of a hypothesis and one score for describing a

controlled experiment to test the same. The maximum score on this task was found to be 9 and the minimum as zero.

### Administration

Then asked Mohan what are the factors upon which depends the drying up of a wet handkerchief? Mohan told then that this question could have many answers, such as :

1. Length;      2. Thickness;    3. Colour;
4. Temperature;    5. Season;
6. Nature of the stuff, i.e., cotton, silk, etc.

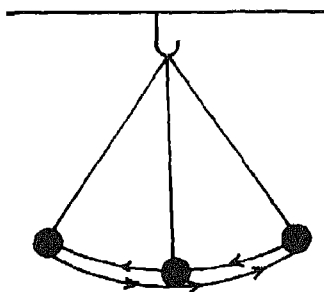
Then then asked Mohan to prove the effect of these factors with the help of the experiments. Mohan stated as follows:



Suppose I am to prove that the drying up of a wet handkerchief depends upon the length of it. I shall take three handkerchieves of the same stuff, same thickness, same colour, etc., but with different lengths. I shall make them equally wet and put them in the sun or shade. The time taken by each handkerchief to dry up will be noted with the help of a watch. If the handkerchief having the smallest length dries up first and the one having the largest length dries up at the last, then it is proved that the drying up of a wet handkerchief depends upon the length of it, otherwise not. Similarly, the effect of the other factors can be proved through the experiments.

Now you please solve the problem given below:

Fig. 6



A simple pendulum is shown in Fig. 6 above. The bob of the pendulum oscillates on both sides of the centre. The movement of the bob from the centre to left end, back to the centre, then to the right end and back to the centre is called the one oscillation of the pendulum. You write down the factors





upon which depends the time taken in one oscillation of the pendulum and prove the effect of each factor through experiments.

### TASK NO. 9

#### Objective

The purpose of the task was to assess the ability of the subjects to visualize the space critically. The performance on the task has been designated as the measure of the space visualization.

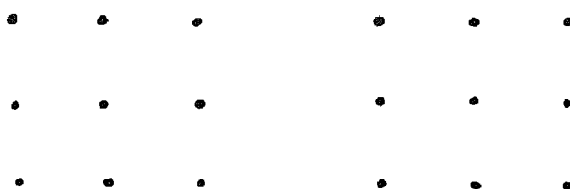
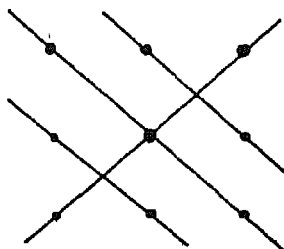
#### Description

This task consisted of a number of sets consisting of nine dots (eight on the four sides of a square and one at the centre). The subjects were required to link all the nine dots with four straight lines only. They were to see that no dot should remain away from the lines and the number of lines should not exceed four in any case. It was an open-ended task. One score was awarded for each correct solution. The maximum score reached on this task was 33 and the minimum was zero.

#### Administration

A number of sets of nine dots are given below (Fig. 7).

Fig. 7





You please try to draw four straight lines in such a way that all the nine dots are touched by one or the other line. Repeat this exercise in as many different ways as you can but the number of lines should not exceed four and no dot should remain untouched.

#### TASK NO. 10

##### Objective

The task was designed to find out if the subjects at formal-operational stage can grasp the essence of the problem. This ability is expected to be developed till adolescence. The measure based on the performance on this task represents the ability to grasp the essence of the problem.

##### Description

This task consisted of five statements which were designed to test whether the subjects could grasp the essence of the problem if posed in a ticklish style. The problems involved in the statements were very simple and easy but they were a bit vexatious question. Thus, if the subjects could sense or grasp the intrinsicity involved then they could reach the solution correctly. One score was awarded for each correct solution. The maximum score on this task came out to be 5 and the minimum as zero.

##### Administration

Read, understand and then answer the questions given below:

1. There is a 10 metre long rod of wood out of which 1 metre rod is cut after every minute. How much time will it take to be cut into pieces of 1 metre length each?



2. Some ducks are swimming in a pond in a straight line. Two ducks are on the front side, two in the middle and two on the backside. How many ducks are there in all?
3. Ham has four friends. Three of his friends are having names as Bryan, John and Tim. What is the name of the fourth friend?
4. There is a blind man. He can see upto 100 metres through one eye. How far will he be able to see through both the eyes?
5. A donkey has two horns. How many horns will be having eight donkeys?

#### Reliability and Validity of the Test of Piaget Type Tasks (Task-wise)

The test re-test reliability coefficients for all the tasks were determined on the basis of re-administration of the test after two months to a group of 50 students. The validity coefficients were worked out for all the ten tasks against the measures of verbal intelligence, non-verbal intelligence and reasoning ability. The results are presented in Table 1.



TABLE 1

COMPUTATION OF RELIABILITY AND VALIDITY OF  
A BATTERY OF PIAGET TYPE TASKS (PART-II)

Task Nos.	N = 50	N = 906		
	Test Retest Reliability Coefficients.	Validity Coefficients Against External Criterion		
		Intelligence Verbal	Intelligence Non-verbal	Reasoning Ability
Task No. 1	.53	.30	.40	.29
Task No. 2	.21	.45	.41	.37
Task No. 3	.33	.54	.53	.43
Task No. 4	.80	.33	.46	.43
Task No. 5	.60	.39	.29	.33
Task No. 6	.43	.42	.32	.36
Task No. 7	.52	.56	.48	.43
Task No. 8	.62	.50	.37	.42
Task No. 9	.63	.30	.33	.26
Task No. 10	.22	.20	.23	.13

## Reliability of the Test of Piaget Type Tasks (Combined)

As suggested by Schwarz and Krug (1972) that the tests which overlap each other provide two separate estimates of the ability common to both and thereby increase the overall accuracy of its appraisal. Thus even the tests of moderate reliability can in combination yield a highly reliable measure of the same. They have suggested that the reliability of the tests in combination can be computed from the individual reliabilities and the inter-test correlations as per following steps:





- Step I Preparation of matrix of tests' reliabilities and inter-correlations.
- Step II Sum of all the elements included in the matrix.
- Step III Replacement of reliability coefficients of individual tests with the value 1.00 in the diagonal entries and sum the matrix again.
- Step IV Division of first sum by the second sum mentioned above.

The resultant figure provides the quotient of the estimated reliability of the test in combination.

The results obtained through this method regarding the reliability of the tasks in combination are presented in Table 2.

TABLE 2

COEFFICIENT OF RELIABILITY OF THE LIST OF  
PIACT TEST ITEMS ( COMBINED )

	1	2	3	4	5	6	7	8	9	10
Task No. 1	.53	.34	.42	.33	.19	.33	.36	.30	.31	.24
Task No. 2	.34	.21	.42	.30	.23	.33	.46	.34	.21	.24
Task No. 3	.42	.42	.35	.45	.30	.43	.51	.43	.34	.33
Task No. 4	.33	.39	.43	.50	.28	.46	.46	.43	.36	.21
Task No. 5	.19	.23	.30	.28	.60	.19	.27	.28	.18	.16
Task No. 6	.33	.33	.43	.46	.19	.43	.33	.42	.35	.21
Task No. 7	.36	.46	.51	.46	.27	.33	.52	.40	.25	.19
Task No. 8	.30	.34	.43	.43	.28	.42	.40	.62	.23	.18
Task No. 9	.31	.21	.34	.36	.18	.35	.25	.23	.63	.19
Task No. 10	.24	.24	.23	.21	.16	.21	.19	.18	.19	.22

Sum of the 100 entries written in the above matrix = 33.24

Sum of the 100 entries after replacing the diagonal entries with 1.00 = 38.28

Coefficient of reliability of the tasks in combination  $\gamma = \frac{33.24}{38.28} = .87$

Thus the value of coefficient of reliability was found to be sufficiently high which proved that the test was quite dependable.



### Validity of the Test of Piaget Type Tasks (Combined)

The procedure to work out the validity of the test in combination was very much similar to that described earlier for estimating the reliability of the tests in combination. Schwars and Brug (1972) has suggested the following steps for the computation of the combined validity:

- Step I        Preparation of the matrix of tests' validities in the diagonal entries and the inter-test correlations.
- Step II       Sum all the validity co-efficients written in the diagonal entries.
- Step III      Replacement of validity co-efficients of individual tests with the value 1.00 in the diagonal entries and sum the matrix again. Computation of the square root of this sum.
- Step IV       Division of first sum by the square root of the second sum.

The resultant value provides the estimate of validity of the tests in combination. The validities, thus, calculated for the combined tasks against the measures of verbal intelligence, non-verbal intelligence and reasoning ability were found to be .69, .63 and .56 respectively which are presented in Tables 3,4 and 5 respectively.



TABLE 3

VALIDITY OF T. A. TEST OF FLIGHT TEST BATTERY  
( DIVIDED ) AGAINST VERBAL INTELLIGENCE

	1	2	3	4	5	6	7	8	9	10
Task No. 1	.33	.34	.42	.33	.19	.33	.36	.30	.31	.24
Task No. 2	.34	.45	.42	.30	.23	.33	.46	.34	.21	.24
Task No. 3	.42	.42	.54	.43	.30	.43	.51	.43	.34	.23
Task No. 4	.33	.39	.45	.53	.23	.46	.46	.43	.36	.21
Task No. 5	.19	.23	.30	.21	.39	.19	.27	.20	.18	.16
Task No. 6	.33	.33	.43	.46	.19	.42	.33	.42	.33	.21
Task No. 7	.36	.46	.51	.46	.27	.33	.36	.40	.25	.19
Task No. 8	.30	.34	.43	.43	.21	.42	.40	.50	.23	.18
Task No. 9	.31	.21	.34	.36	.18	.35	.25	.23	.30	.19
Task No. 10	.24	.24	.23	.21	.16	.21	.19	.19	.19	.20

Sum of validity coefficients written  
in the diagonal entries

= 4.27

Sum of the 100 entries after replacing the  
diagonal entries with 1.00

= 38.23

Square root of the second sum

= 6.187

Coefficient of validity of the tasks in  
combination against the criterion of  
verbal intelligence

$\gamma$  = .69



TABLE 4

VALIDITY OF P. L. TEST OF MENTAL XEN. TASKS  
( CRITERION ) AGAINST NON-VERBAL INTELLIGENCE

	1	2	3	4	5	6	7	8	9	10
Task No. 1	.41	.34	.42	.35	.19	.33	.36	.21	.31	.24
Task No. 2	.34	.41	.42	.39	.33	.33	.46	.34	.21	.24
Task No. 3	.42	.42	.53	.45	.30	.45	.51	.43	.34	.23
Task No. 4	.33	.39	.43	.46	.21	.46	.46	.43	.36	.21
Task No. 5	.19	.23	.30	.21	.29	.19	.27	.21	.18	.16
Task No. 6	.33	.33	.43	.46	.19	.32	.31	.42	.35	.21
Task No. 7	.36	.46	.51	.46	.27	.33	.41	.40	.23	.19
Task No. 8	.21	.34	.43	.43	.23	.42	.40	.37	.23	.18
Task No. 9	.31	.21	.34	.36	.18	.35	.25	.23	.33	.19
Task No. 10	.24	.24	.23	.21	.16	.21	.19	.18	.19	.23

Sum of validity coefficients written  
in the diagonal entries

= 3.21

Sum of the 100 entries after replacing  
the diagonal entries with 1.00

= 38.20

Square root of the second sum

= 6.187

Coefficient of validity of the tasks in  
combination against the criterion  
of non-verbal intelligence.

$\gamma$  = .62





TABLE 5

VALIDITY OF THE TESTS OF LOGIC PLANS  
( COMBINED ) AGAINST REASONING ABILITY

	1	2	3	4	5	6	7	8	9	10
Task No. 1	.39	.34	.42	.33	.19	.33	.36	.39	.31	.24
Task No. 2	.34	.37	.43	.30	.23	.33	.46	.34	.21	.24
Task No. 3	.42	.42	.42	.47	.30	.43	.31	.43	.34	.23
Task No. 4	.33	.30	.43	.45	.20	.46	.46	.43	.36	.21
Task No. 5	.19	.23	.30	.21	.22	.19	.27	.21	.18	.16
Task No. 6	.33	.33	.43	.46	.19	.36	.33	.42	.35	.21
Task No. 7	.36	.46	.51	.46	.27	.33	.43	.40	.25	.19
Task No. 8	.39	.34	.43	.43	.21	.42	.40	.42	.23	.18
Task No. 9	.31	.21	.34	.36	.18	.38	.23	.23	.26	.19
Task No. 10	.24	.24	.23	.21	.16	.21	.19	.18	.19	.13

Sum of the validity coefficients  
written in the diagonal entries = 3.48

Sum of the 100 entries after replacing  
the diagonal entries with 1.00 = 39.28

Square root of the second sum = 6.167

Coefficient of validity of the tasks  
in combination against the criterion  
of reasoning ability  $Y = .55$



## CHAPTER 3

## Description of the Other Tests Used

In addition to the Test of Piaget Type Tasks described earlier, some other standard psychological tests were also included in the study to explore the allied dimensions of formal-operational thought and to make the process of interpretations of factors more sound. The description of these tests are given below:

## Cattell's Culture Fair Intelligence Test (Scale 3)

The purpose of the test, according to the authors, is to provide a single best measure of intelligence as the modern basis for the general intelligence having the highest validity on Thurstone's second order general ability factor or Spearman's 'g' (general mental capacity). The test, therefore, deals with the core of general relation education capacity which many researchers have shown to be largely inborn, a relatively constant characteristic for the individual and operative in quite different fields of content, e.g., verbal, numerical, spatial and social skills. The authors claim that the test is highly suitable for the varied research situation, especially for those in which general ability is the variable to be operated. It measures intelligence in separation from chance educational influences and local social climate.

The scale consists of 46 problems in all, covered under 4 sub-tests, i.e., series (12), classifications (14), matrices (12) and conditions (8). In all the sub-tests, the items are arranged



in order of increasing difficulty. It is available in two equivalent forms, A and B. This assumes the standard 'speeded test' administration in which the time limit is accurately adhered to for each sub-test as 3,4,4 and 2.5 minutes respectively. Scale 2 is designed for eight through fourteen year olds and for unselected (non-college) adults. It may be used both as an individual and as a group test.

Authors have reported that the reliability of the scale, both in terms of the Dependability Coefficient and the Consistency Coefficient, was evaluated. The Dependability Coefficient (immediate test re-test agreement) on the full test was found to be ranging from .82 to .85. The Consistency Coefficient (split-half, corrected to full length using both A and B forms) for four different groups was ranging between .70 and .92. The validity of the test can be envisaged from the fact that it has given 'r' values of .56 to .71 with the Revised Stanford Binet, of .73 with the Otis Quick Scoring Test and of .59 with A.C.L. The measure of intelligence (non-verbal) based on the scores obtained on this test has been denoted by the code IW.

#### Jalota's General Mental Ability Test

It is a group test of general mental ability which can be administered to Hindi knowing school children. The test consists of 100 items distributed over the elements of Vocabulary - Similar (10), Vocabulary-Opposites (10), Number-Series (20), Classification (20), Best Answers (10), Inferences (10) and Analogies (20). The items are presented on a homogeneous format, i.e., the items belonging to different elements are inter-



arranged. The time allowed to answer 100 items is 30 minutes. The reliability of the test has been reported to be .938. The validity coefficients of the test with respect to school examination marks ranged from .50 to .70. The measure of intelligence based on the performance on this test is given the code IV.

#### **Lubay's Reasoning Ability Test**

The author has claimed that the test is a good measure of reasoning ability associated with problem solving. The test contains 60 items. First 40 items are number series in which last two spaces are to be filled in by the subjects. Thus, these items have two answers for each item and hence carry 80 scores. The next 20 items represent problems, and each carries one mark for correct answer. The time limit for the test is 60 minutes. It is meant for students knowing Hindi and of 12-17 years of age. The reliability coefficients of the test have been reported as .896 and .913 for National Equivalence Method and Split-half Method respectively. The validity coefficients of the test with respect to the external criteria such as Group Test of Intelligence (R.K.Tandon), Progressive Matrices and Problem Solving Ability Test have been reported to be .875, .836 and .882 respectively.

#### **Asthana's Adjustment Inventory**

The inventory attempts to segregate the poorly adjusted from those who are better adjusted. It works as a quick screening device for use with the Hindi knowing school and college students. The inventory consists of 40 items excluding





items 29 and 34. It has no fixed time limit. It takes about 30 minutes to answer all the items. The inventory is self-administering. The examinees are to interpret the questions for themselves. However, the meanings of the difficult words were explained by the investigator to the younger subjects. The scoring was done awarding one score for 'No' and zero for 'Yes' responses except for items 19 and 40 where it was in the reverse order as described by the author. The reliability coefficient by split-half method has been reported to be .97. The validity index of the test items determined through bi-serial correlation technique using total test score as criterion measure has been reported to be satisfactory.

#### Cattell's High School Personality Questionnaire (HSPQ)

The HSPQ is a standard instrument that gives an objective analysis of fourteen distinct dimensions of personality.\* The author has a claim that these fourteen dimensions have been found to be covering almost the total personality. Form A of the Hindi version of the HSPQ (Kapoor and Mehrotra, 1967) was used in the study under report. It consists of 114 items, all of multiple choice. The reading level of the test is adapted to ages 11 or 12 through 16 years. No time limit has been suggested but all the students were able to complete it in about 30 minutes. The immediate test re-test reliability coefficients (dependability

---

\* For the description and the codes of the fourteen dimensions of personality as well as other variables, see appendix (iv).



coefficients) for the fourteen dimensions have been reported to be ranging from .74 to .91 and test retest reliability coefficients after six months period (stability coefficients) range from .53 to .69. The coefficients of validity (construct) range from .57 to .77 for the fourteen dimensions.

#### Space Relations Test (SRT)

The Differential Aptitude Tests' battery was developed by Bennett, et al (1939). The battery was designed for use with high school students. The Differential Aptitude Test consists of eight tests designed to measure eight different abilities : verbal reasoning, numerical ability, space relations, abstract reasoning, clerical speed and accuracy, mechanical reasoning, language usage and spelling and sentences. In the study at hand only the space relations test was used. It measures abilities to visualize a constructed object from a pattern and to manipulate a form in order to judge its appearance after rotation in various ways. The space relations test consists of 60 items only. The testing time for the test is 35 minutes. Split-half reliability of the test has been reported to be .93 by the authors. Validity coefficient of the test against the science grades was lying between .40 and .50.

#### Academic Achievement in School Subjects

The measures of academic achievement in five school subjects, i.e., Mathematics, Science, English, Punjabi and Hindi were based on the scores of the students obtained at examinations conducted by the schools. Since the standard of examination varies from school



to school, therefore, the scores of all the five subjects were converted into standard scores for each class. The scores of all the five subjects were kept separate as it is understood that each subject requires a specific sort of psychic abilities. The separate scores of the different subjects may also be helpful in the identification and explanation of the factors extracted through factor analysis. The examination scores of five school subjects were treated just as the performance on a battery of five tests and hence the reliability of the overall measure of academic achievement was worked out, from the average coefficient of inter-subject correlations which came out to be .44, by applying the formula :

reliability of the overall measure  
of academic achievement

$$r = \frac{nr'}{1-(n-1)r'}$$

where  $n$  = number of tests taken

$r'$  = average coefficient of inter-  
subject correlations.

The coefficient of reliability of the overall measure of academic achievement was found to be .80. The validity coefficients for the overall measure of academic achievement were found to be .36, .52 and .30 respectively against the external criteria of verbal intelligence, non-verbal intelligence and reasoning ability respectively when computed by the method described earlier for the validity of the Test of Piaget Type Tasks.



## CHAPTER V

# Results of Descriptive Statistics and Bivariate Analysis





## CHAPTER V

Results of Descriptive Statistics and  
Bivariate Analysis

## Section A

## Results of Descriptive Statistics

It was thought desirable to present the results of the descriptive statistics in terms of mean, median, mode, standard deviation, standard error, kurtosis and skewness regarding the various measures included in this study before presenting the actual results related to the hypotheses as the former may be considered good indicators of the attributes essential for the fulfilment of the assumptions underlying the theoretical framework of the statistical techniques employed for the analysis of data. These statistics were computed, using the programme **STATISTICAL** with **ALL STATISTICS** from the Statistical Package for the Social Sciences (Nie, et al., 1970), through the 'ASXAP - 1022 Computer' at Computronics India, New Delhi. To furnish a clear picture of the distributions of the measures of personality, academic achievement, adjustment, intelligence, space relations, reasoning ability and adolescent thought, the results regarding the descriptive statistics have been presented in the tabular form as follows:



TABLE 6

THE VALUES OF MEAN, MEDIAN, MODE, STANDARD DEVIATION,  
STANDARD ERROR, KURTOSIS AND SKURTOSIS FOR SEVENTEEN  
DIMENSIONS OF PERSONALITY ( 199 )

Dimension of Perso- nality	Mean	Median	Mode	SD	SE	Ku	Sk
A	9.495	9.604	10.000	2.596	.083	.036	-.083
B	3.134	3.076	3.000	1.398	.045	.144	.273
C	8.754	8.659	8.000	3.697	.086	-.240	-.006
D	7.665	7.737	8.000	3.761	.088	-.217	-.015
E	7.333	7.555	8.000	2.552	.081	-.207	-.078
F	9.902	9.033	10.000	2.571	.082	-.011	-.171
G	9.718	9.723	8.000	2.698	.086	-.237	-.016
H	8.512	8.404	8.000	2.919	.093	-.153	-.009
I	7.806	7.873	8.000	2.743	.087	-.108	-.041
J	7.743	7.723	8.000	2.321	.080	-.210	.008
K	6.818	6.800	8.000	2.315	.093	-.475	.006
L <sub>1</sub>	7.548	7.756	8.000	2.750	.088	.020	-.155
L <sub>2</sub>	8.933	8.907	10.000	2.797	.089	-.002	-.068
L <sub>3</sub>	7.266	7.500	6.000	3.803	.089	-.270	-.095

The results presented in Table 6 make it quite clear that the values of mean and median for all the dimensions of personality were in close agreement with each other. The values of SDs were found to be varying between 2.521 and 2.919 for all the measures except the one (B) whose SD was 1.398. The values of standard errors of mean were found to be ranging from .045 to .093 which



demonstrated the stability of all the measures of personality. The values of kurtosis were found to be varying between  $-.002$  and  $+.475$  for the eleven dimensions ( $Q_1, Q_2, Q_3, Q_4, Q_5, Q_6, Q_7, Q_8, Q_9, Q_{10}$  and  $Q_{11}$ ) and for the remaining three dimensions ( $A_1, A_2$  and  $A_3$ ) between  $.020$  and  $.144$ . The indices of skewness were found to be ranging between  $-.171$  and  $.273$ . Since the indices of skewness and kurtosis were having small magnitudes in the case of the majority of the measures and the values of mean and median showed a good harmony with one another for all the measures, the measures of personality may be considered as normally distributed.

TABLE 7

THE VALUES OF MEAN, MEDIAN, MODE, STANDARD DEVIATION, VARIATION COEFFICIENT, KURTOSIS AND SKEWNESS FOR FIVE MEASURES OF ACADEMIC ACHIEVEMENT

Measure of Academic Achievement	Mean	Median	Mode	SD	SE	Ku	Sk
AAI	50.229	50.234	47.000	9.598	.306	-.506	.016
AAS	50.306	50.419	48.000	9.693	.309	-.474	-.054
AAE	50.528	50.405	49.000	9.435	.301	-.468	.015
AAI'	50.373	50.183	48.000	9.485	.302	-.432	-.000
AAT	50.443	50.441	52.000	9.564	.305	-.442	.022

It is evident from the results presented in Table 7 that for all the five measures of academic achievement the values of mean and median were identical (lying between 50.183 and 50.528).



The values of SD<sub>s</sub> were found to be ranging between 9.433 and 9.693. The standard errors of mean ranged from .301 to .309 for the five measures. The values of kurtosis were found to be lying between -.432 and -.506, and thus the measures were leptokurtic. The indices of skewness were ranging between -.054 and .022 which demonstrated that the measures of academic achievement were evenly distributed.

TABLE 8

THE VALUES OF MEAN, MEDIAN, MODE, STANDARD DEVIATION, STANDARD ERROR, KURTOSIS AND SKEWNESS FOR THE MEASURES OF ADJUSTMENT, VERBAL INTELLIGENCE, NON-VERBAL INTELLIGENCE, SPACE RELATIONSHIP AND REASONING ABILITY.

Measure	Mean	Median	Mode	Standard Deviation	Standard Error	Kurtosis	Skewness
ADJ	20.738	20.894	18.000	5.448	.173	.250	-.183
IV	19.476	17.833	17.000	9.068	.314	2.367	1.084
IN	16.144	15.764	13.000	5.815	.178	.020	.250
VI	24.408	24.069	25.000	5.261	.263	.039	.254
RA	12.664	11.867	10.000	5.373	.171	10.335	2.163

The results presented in Table 8 have established that the measure of adjustment (ADJ) was normally distributed, as the values of mean (20.738) and median (20.894) were found to be identical, and the indices of skewness (-.183) and kurtosis (.250) were not deviated from the normal values considerably. The values of IV and IN were found to be 5.448 and .173 respectively.





The measure of verbal-intelligence (IV) was found to be positively skewed as the median (17.833) was lying to the left of the mean (19.476) and the value of skewness was found to be 1.084 (vide Table 8). The measure had SD equal to 9.868 and SE of mean equal to .314. The measure was platykurtic as the value of kurtosis was found to be 2.367.

It is evident from the results presented in Table 8 that the distribution of the measure of non-verbal intelligence (ENV) was normal, as the values of mean (16.144) and median (15.764) were in close vicinity of each other, and the values of kurtosis (.080) and skewness (.250) were also close to the normal values. The values of SD and SE were found to be 5.513 and .176 respectively.

Looking through the results presented in Table 8, it was found that the values of mean (24.483) and median (24.069) of the measure of space relations (SI) were in close agreement with each other, and the values of kurtosis (.069) and skewness (.264) were also within the acceptable limits. Hence the distribution of the measure may be considered normal. The SD of the measure was found to be 5.261 and the SE of mean as .263.

The results presented in Table 8 show that the measure of reasoning ability (RA) was positively skewed, as the value of median (11.867) was found to be lying to the left of the value of mean (12.664), and the index of skewness was found to be 2.163. The value of kurtosis was found to be 10.386 which showed that the measure was platykurtic. The values of SD and SE were found to be 5.373 and .171 respectively.



TABLE 9

VALUES OF MEAN, MEDIAN, MODE, STANDARD DEVIATION,  
STANDARD ERROR, COEFFICIENT AND SKEWNESS FOR  
THE TEN MEASURES OF ADOLESCENT THOUGHT

Measure of Adolescent Thought	Mean	Median	Mode	SD	SE	Sk	Sk
CL	33.590	33.346	34.000	18.093	.576	-1.199	-.335
GT	2.441	2.407	.000	1.833	.088	-.863	.268
GAA	11.292	11.304	.000	6.995	.223	-1.199	-.039
PAC	2.423	1.715	.000	2.625	.084	.819	1.738
RA	1.170	0.000	.000	2.152	.069	1.779	1.791
WPQ	5.453	5.211	.000	4.236	.135	-.180	.533
ICI	3.739	2.843	2.000	2.987	.095	-.992	.502
STI	1.829	1.547	.000	1.862	.089	.738	.962
W	8.439	7.954	9.000	4.731	.151	.790	.801
GA	.977	.764	.000	1.093	.035	.505	1.019

The results presented in Table 9 demonstrate that the values of mean and median for the measures of adolescent thought were in close agreement with each other except in the case of the three measures, namely, permutations and combinations (PAC), ratio and proportion (RA), and grasping the essence of the problem (GA) where the variations were quite marked. The values of skewness were found to be ranging from -.335 to 1.791. The measure of classification (CL) was negatively skewed; the measures of permutations and combinations (PAC), ratio and proportion (RA), formulation of probing questions (WPQ), interpretation and coordination of information (ICI), stating and testing of



hypothesis (TH), space visualization (SV) and grasping the essence of the problem (GE) were positively skewed; and the measures of grouping of thought (GOT) and generalization to arithmetical and algebraic symbols (GAA) were normal. The indices of kurtosis were found to be varying from -1.999 to 1.779. The measures of classification (C), grouping of thought (GOT), generalization to arithmetical and algebraic symbols (GAA) and interpretation and coordination of information (ICI) were leptokurtic and the measures of permutations and combinations (PC), ratio and proportion (RAP), stating and testing hypotheses (STH), space visualization (SV) and grasping the essence of the problem (GE) were platykurtic and the measure of formulation of probing questions (FP) was mesokurtic.

A close view of the nature of the distributions of the various measures described in the preceding section reveals that in most of the cases the distributions were normal with little variations. Thus for the further statistical analysis all the measures have been assumed to be normally distributed with respect to the population under study.



## Section B

### Results of Bivariate Analysis

The data were analysed through bivariate analysis in order to test hypotheses 1 to 7. The results are presented below as per sequence of the hypotheses stated earlier.

The first hypothesis of the study was : Does the performance on Piaget Type Tasks increase with age during the formal-operational period? The data regarding the performances on various Piaget Type Tasks at different age levels ( 11<sup>+</sup>, 12<sup>+</sup>, 13<sup>+</sup>, 14<sup>+</sup> and 15<sup>+</sup> years) were put to one way analysis of variance to determine the significance of the variations in the performances on Piaget Type Tasks at different age levels. The F-ratios computed for all the ten Piaget Type Tasks have been presented in Table 10.

It is evident from the results presented in Table 10 that all the F ratios were significant at  $<.01$  level which proved that significant differences exist between the performance of the students at 11<sup>+</sup>, 12<sup>+</sup>, 13<sup>+</sup>, 14<sup>+</sup> and 15<sup>+</sup> age levels for the tasks of classification (CL), grouping of thought (GOT), generalisation to arithmetical and algebraic symbols (GAS), permutations and combinations (PAC), ratio and proportion (RAP),





TABLE 10

RELATION OF THE ANALYSIS OF VARIANCE ATTACHED TO FIVE AGE LEVELS AND THE PERFORMANCE ON EACH OF THE TEN DICTIONARY TASKS

Task	Variable	Sum of Squares	Degrees of Freedom	Mean Square	F	Total Sig. (2-tailed)
CL	Between Groups	39706.750	4	9926.687	34.569	< .01
	Within Groups	332341.261	981	337.809		
GOT	Between Groups	841.534	4	210.383	82.160	< .01
	Within Groups	2512.013	981	2.561		
GAA	Between Groups	13872.227	4	3468.057	93.199	< .01
	Within Groups	34925.641	981	35.502		
PAJ	Between Groups	1891.336	4	472.834	75.145	< .01
	Within Groups	8193.615	981	8.354		
RAP	Between Groups	527.353	4	131.833	32.051	< .01
	Within Groups	4034.022	981	4.112		
FPJ	Between Groups	4396.576	4	1096.669	80.955	< .01
	Within Groups	13237.687	981	13.445		
ICI	Between Groups	2332.273	4	583.068	88.602	< .01
	Within Groups	6465.745	981	6.591		
STJ	Between Groups	279.550	4	69.888	55.110	< .01
	Within Groups	2534.434	981	2.584		
SV	Between Groups	2539.418	4	634.854	27.745	< .01
	Within Groups	22446.705	981	22.881		
QAP	Between Groups	45.227	4	11.307	9.630	< .01
	Within Groups	1151.772	981	1.174		



formulation of probing questions (FPQ), interpretation and coordination of information (ICI), stating and testing hypotheses (STH), space visualisation (SV) and grasping the essence of the problem (GP).

The dimensions of adolescent thought included in this study show a trend of growth during the formal operational period (vide Table 11). Though in the beginning it was mentioned that some of the tasks related to <sup>the</sup> concrete-operational stage such as tasks of classification and grouping of thought were included just to maintain continuum of the measures of adolescent thought, but the findings of this study revealed that even these dimensions had not reached the state of perfection till late adolescence. Thus the earlier findings of the research workers (Dale, 1970; Dulit, 1972; Higgings and Gaite, 1971; Keatings, 1975; Lawson and Renner, 1974; Lawson and Blöte, 1975; Renner and Stafford, 1972) that not only high school students but college students and in some cases teachers also were found operating at concrete-operational stage, seem quite convincing in the light of the results of the present study. The positive skewness in the case of the measures of ratio and proportion (RAP), grasping the essence of the problem (GP), stating and testing hypotheses (STH) and space visualisation (SV) does indicate that the majority of the scores on these measures of adolescent thought were lying on the lower side of the mean of the scale (vide Table 9), which implicitly demonstrate that these dimensions have not been developed substantially among the subjects tested.



TABLE 11

MEAN SCORE AND STANDARD DEVIATION OF AAC I  
TASK AT DIFFERENT AGE LEVELS

Piglet Type Task	Age in Years					Overall Total
	11 <sup>+</sup>	12 <sup>+</sup>	13 <sup>+</sup>	14 <sup>+</sup>	15 <sup>+</sup>	
	N = 160	205	225	213	175	986
CL	22.125 (16.498)	30.815 (17.076)	34.327 (17.711)	30.363 (16.488)	40.749 (16.892)	33.740 (18.084)
OOT	1.006 ( 1.323)	1.707 ( 1.547)	2 .531 ( 1.804)	3.200 ( 1.671)	3.657 ( 1.534)	2.445 ( 1.843)
OAA	5.744 ( 5.470)	8.659 ( 5.936)	10.735 ( 6.588)	15.269 ( 5.610)	15.606 ( 6.069)	11.292 ( 6.995)
PAC	.631 ( 1.561)	1.342 ( 1.871)	2.227 ( 2.234)	3.660 ( 2.566)	4.086 ( 2.994)	2.425 ( 2.625)
RAV	.232 ( .553)	.595 ( 1.720)	.898 ( 1.832)	2.094 ( 2.614)	1.977 ( 2.560)	1.170 ( 2.152)
W77	2.202 ( 3.006)	3.620 ( 3.120)	6.120 ( 3.961)	6.570 ( 3.784)	8.399 ( 4.249)	5.453 ( 4.236)
ICI	1.577 ( 1.796)	2.454 ( 2.299)	3.504 ( 2.689)	5.443 ( 2.953)	5.560 ( 2.260)	3.739 ( 2.987)
STH	.494 ( .882)	1.039 ( 1.271)	1.766 ( 1.590)	2.580 ( 1.880)	3.205 ( 2.091)	1.829 ( 1.862)
SV	5.691 ( 3.869)	7.971 ( 4.734)	8.287 ( 4.682)	10.488 ( 4.543)	9.874 ( 4.789)	8.520 ( 5.037)
GSF	.679 ( .968)	1.005 ( 1.080)	.960 ( 1.144)	.962 ( .937)	1.306 ( 1.236)	.999 ( 1.102)

Standard Deviations are given in brackets.









It is clear from the results presented in Table 11 that the performances of the students at different age levels ( 11<sup>+</sup>, 12<sup>+</sup>, 13<sup>+</sup>, 14<sup>+</sup> and 15<sup>+</sup> years ) show <sup>an</sup> increasing trend for almost all the tasks, which is more evident from the Fig. 8.

Thus, it has been confirmed that the students of the age group 11 to 15 years have not reached the formal-operational level to its full as they have been found to be still growing. It has been concluded that performance on Piaget Type Tasks increases with age during the formal-operational period. The first hypothesis, thus, stands empirically verified and declared affirmatively.

Regarding the second hypothesis: whether boys and girls perform equally well on Piaget Type Tasks 7, the performances of boys and girls on Piaget Type Tasks at different age levels as well as for the combined groups were analysed using t-test technique to determine the significance of the difference between them. The results, thus computed, regarding the performances on ten Piaget Type Tasks have been presented in Tables 12 to 21.

It is evident from the results presented in Table 12 that sex differences were quite obvious at age levels 11<sup>+</sup>, 12<sup>+</sup> and 13<sup>+</sup> where boys have shown better performance than girls on the task of classification (CL). At 14<sup>+</sup> and 15<sup>+</sup> age levels no significant difference was found between the performance of boys and girls. Thus, it is very interesting to note that the



TABLE 12

RESULTS REGARDING THE COMPARATIVE PERFORMANCE OF BOYS  
AND GIRLS ON THE TASK OF CLASSIFICATION AT FIVE  
AGE LEVELS AS WELL AS FOR THE COMBINED GROUPS

Age level in Yrs.	Sex	N	Mean Perfor- mance	SD	Difference of Means (D)	$Z_p$	t	Level of Signi- ficance
11 <sup>+</sup>	B	88	24.909	16.011	5.846	2.520	2.320	*
	G	80	19.063	16.381				
12 <sup>+</sup>	B	105	34.914	17.272	8.404	2.313	3.633	**
	G	100	26.510	15.840				
13 <sup>+</sup>	B	116	37.716	17.078	6.961	2.518	3.003	**
	G	110	30.755	17.740				
14 <sup>+</sup>	B	103	30.925	16.303	1.147	2.269	.503	n.s
	G	104	29.779	16.445				
15 <sup>+</sup>	B	88	41.552	17.092	2.220	2.531	.870	n.s
	G	87	39.532	16.650				
Com- bined	B	505	36.095	17.688	4.827	1.143	4.223	**
	G	481	31.258	18.184				

\* Significant at .05 level

\*\* Significant at .01 level

n.s Not significant



TABLE 13

REPRESENTATIVE THE COMPARATIVE PERFORMANCE OF  
BOYS AND GIRLS ON THE TASK OF TROUPEING OF 2 D M E  
AT THE FIVE AGE LEVELS AS WELL AS FOR THE COMBINED  
GROUP

Age Level in Yrs.	Sex	N	Mean Perfor- mance	SD	Difference of Means (t)	SD	t	Level of Signi- ficance
11 <sup>+</sup>	B	88	.933	1.192	-.156	.207	.753	n.s
	G	80	1.030	1.460				
12 <sup>+</sup>	B	105	1.762	1.451	.112	.218	.514	n.s
	G	100	1.650	1.643				
13 <sup>+</sup>	B	116	2.612	1.883	.156	.240	.692	n.s
	G	110	2.446	1.722				
14 <sup>+</sup>	B	108	3.259	1.672	.125	.230	.544	n.s
	G	104	3.144	1.675				
15 <sup>+</sup>	B	88	3.830	1.533	.347	.251	1.508	n.s
	G	87	3.493	1.524				
Com- bined	B	505	2.408	1.853	.102	.117	.859	n.s
	G	481	2.393	1.827				

n.s Not significant.



TABLE 14

RESEARCH REGARDING THE OPERATIVE RECOGNITION OF DEEP AND  
 GENTLE ON "H" TASK OF GENERALIZATION TO GENTLE FLIGHT AND  
 ANGERIC STIMULI AT THE FIVE AGE LEVELS AS SET AS FOR  
 THE COMBINED GROUPS

Age Level in Yrs.	Sex	N	Mean Perfor- mance	(S)	Difference of Means (D)	S.D	t	Level of Signi- ficance
11 <sup>+</sup>	B	88	5.693	5.476	-.107	.649	.126	n.s
	G	80	5.800	5.515				
12 <sup>+</sup>	B	105	9.543	5.786	1.813	.823	2.203	*
	G	100	7.730	6.008				
13 <sup>+</sup>	B	116	11.370	6.402	1.324	.871	1.531	n.s
	G	110	10.055	6.587				
14 <sup>+</sup>	B	103	15.991	5.559	1.472	.756	1.932	n.s
	G	104	14.519	5.590				
15 <sup>+</sup>	B	82	16.952	5.164	2.714	.898	3.022	**
	G	87	14.241	6.619				
Com- bined	B	503	11.964	6.985	1.370	.444	3.105	**
	G	491	10.886	6.944				

\* Significant at .05 level.

\*\* Significant at .01 level.

n.s Not significant.





TABLE 15

RESULTS REGARDING THE DIFFERENTIAL PERFORMANCE OF BOYS AND GIRLS ON THE TASK OF PERIMETERING AND COMBINING AT THE FIVE AGE LEVELS AS WELL AS FOR THE COMBINED GROUP

Age level in Yrs.	Sex	N	Mean Performance	SD	Difference of Means (D)	SE <sub>D</sub>	t	Level of significance
11 <sup>+</sup>	B	80	1.796	1.013	.346	.234	1.477	n.s.
	G	80	1.450	1.023				
12 <sup>+</sup>	B	103	1.548	2.035	.623	.256	2.453	*
	G	100	1.020	1.553				
13 <sup>+</sup>	B	116	2.618	2.490	.640	.249	2.604	**
	G	110	1.954	1.896				
14 <sup>+</sup>	B	108	4.157	2.590	1.013	.346	2.929	**
	G	104	3.144	2.459				
15 <sup>+</sup>	B	88	5.080	3.029	1.999	.427	4.676	**
	G	87	3.081	2.611				
Combined	B	505	2.855	2.956	.862	.164	5.351	**
	G	491	1.973	2.251				

\* Significant at .05 level.

\*\* Significant at .01 level.

n.s. Not significant.



TABLE 16

RESULTS OF COMPARISON OF COMPARATIVE TESTS OF 11-17  
AND 18-19 YEAR OLD MALES OF RATIO AND PROPORTION AT FIVE  
FIVE AGE LEVELS AS WELL AS TOTAL COMBINED GROUP

Age level in Yrs.	Sex	N	Mean Perfor- mance	SD	Difference of Means (t)	df	t	Level of Signi- ficance
11*	M	88	.351	.397	.061	.006	.712	n.s
	F	80	.300	.513				
12*	M	109	.619	2.070	.450	.235	1.945	n.s
	F	100	.360	1.219				
13*	M	116	1.509	2.324	1.234	.232	5.402	**
	F	110	.255	.893				
14*	M	103	2.598	2.862	1.633	.340	4.522	**
	F	104	1.350	2.019				
15*	M	88	2.796	2.801	1.647	.367	4.496	**
	F	87	1.149	1.986				
Com- bined	M	503	1.669	2.513	1.022	.132	7.676	**
	F	451	.647	1.525				

\*\* Significant at .01 level.

n.s Not significant.



TABLE 17

RESULTS REGARDING THE COMPARATIVE PERFORMANCE OF BOYS  
AND GIRLS ON THE TASK OF REGULATION OF POKING PL. TEST  
AT THE FIVE AGE LEVELS AS WELL AS FOR THE COMBINED GROUPS

Age Level in Yrs.	Sex	N	Mean Perfor- mance	SD	Difference of Means (D)	SD <sub>D</sub>	t	Level of Signi- ficance
11 <sup>+</sup>	B	83	2.693	3.302	1.030	.453	2.271	*
	G	80	1.663	2.555				
12 <sup>+</sup>	B	105	4.267	3.369	1.527	.436	3.039	**
	G	100	2.940	2.870				
13 <sup>+</sup>	B	116	6.586	3.918	.959	.524	1.830	n.s.
	G	110	5.627	3.967				
14 <sup>+</sup>	B	108	7.355	3.937	1.825	.504	3.617	**
	G	104	5.740	3.393				
15 <sup>+</sup>	B	88	9.205	4.142	1.642	.632	2.597	**
	G	87	7.563	4.220				
Com- bined	B	505	6.091	4.347	1.507	.256	4.900	**
	G	481	4.784	4.013				

\* Significant at .05 level.  
 \*\* Significant at .01 level.  
 n.s. Not significant.



TABLE 18

RESEARCH REGARDING THE SEPARATE PERFORMANCE OF  
BOYS AND GIRLS ON "A" TASK OF INTERPOLATION AND  
COMBINATION OF INFORMATION IN THE CIVIL AIR SERVICE  
AS WELL AS THEIR REBUILT GROUPS

Age level in Yrs.	Sex	N	Mean Perfor- mance	SD	Difference of Means (D)	$\chi^2$	p	Level Signi- ficance
11 <sup>+</sup>	B	83	1.591	1.733	.028	.279	.100	n.s
	G	80	1.563	1.875				
12 <sup>+</sup>	B	105	2.514	2.175	.124	.322	.324	n.s
	G	100	2.390	2.432				
13 <sup>+</sup>	B	116	3.809	2.691	.008	.333	.025	n.s
	G	110	3.500	2.998				
14 <sup>+</sup>	B	108	5.815	2.836	.757	.404	1.873	n.s
	G	104	5.058	3.036				
15 <sup>+</sup>	B	88	5.909	2.659	.702	.422	1.664	n.s
	G	87	5.207	2.922				
Com- bined	B	505	3.879	2.059	.236	.190	1.507	n.s
	G	481	3.593	2.981				

n.s Not significant.





TABLE 19

EXPERIMENT RECORDING THE COMPARATIVE RECEPTIVITY OF BOYS  
AND GIRLS ON THE TASK OF HEATING AND COOLING  
WATER TIGHT AT THE FIVE AGE LEVELS AS WELL AS FOR THE  
COMBINED GROUP

Age level in Yrs.	Sex	N	Mean Perfor- mance	SD	Difference of Means (t)	SD	t	Level of Signifi- cance
11 <sup>+</sup>	B	88	.443	.706	-.107	.138	.777	n.s
	G	80	.550	.970				
12 <sup>+</sup>	B	108	.971	1.173	-.130	.179	.780	n.s
	G	100	1.110	1.370				
13 <sup>+</sup>	B	116	1.905	1.604	.207	.210	1.368	n.s
	G	110	1.618	1.478				
14 <sup>+</sup>	B	103	2.851	1.811	.773	.286	3.014	**
	G	104	2.079	1.914				
15 <sup>+</sup>	B	88	3.854	1.901	1.324	.301	4.401	**
	G	87	2.530	2.073				
Com- bined	B	505	2.003	1.941	.353	.117	3.009	**
	G	481	1.647	1.750				

\*\* Significant at .01 level.

n.s Not significant.



TABLE 20

RESULTS REGARDING THE COMPARATIVE PERFORMANCE OF BOYS  
AND GIRLS ON THE TASK OF SPIRO VENTILATION AT THE  
SEVERAL AGE LEVELS AS WELL AS FOR THE COMBINED GROUPS

Age Level in Yrs.	Sex	N	Mean Perfor- mance	SD	Difference of Means (D)	SE	t	Level of Signifi- cance
11 <sup>+</sup>	B	80	6.432	4.301	1.557	.380	2.603	**
	G	80	4.875	3.305				
12 <sup>+</sup>	B	105	9.010	6.666	2.230	.770	3.064	**
	G	100	6.880	4.372				
13 <sup>+</sup>	B	116	8.793	5.142	1.102	.615	1.790	n.s.
	G	110	7.691	4.086				
14 <sup>+</sup>	B	103	11.620	4.645	2.400	.603	3.999	**
	G	104	9.231	4.120				
15 <sup>++</sup>	B	88	11.000	4.002	2.425	.702	3.452	**
	G	87	8.555	4.432				
Com- bined	B	505	9.434	5.430	1.873	.314	5.936	**
	G	481	7.561	4.327				

\*\* Significant at .01 level.

n.s. Not significant.



TABLE 21

RESULTS REGARDING THE COMPARATIVE EFFECTIVENESS OF  
DOIT AND GIVE ON THE TASK OF GRATING T L  
RESULTS OF THE SUBJECTS AT THE FIVE AC LEVELS AS  
WELL AS FOR THE COMBINED GROUP

Age Level in Yrs.	Sex	N	Mean Perfor- mance	SD	Difference of Means (D)	$\sigma_D$	t	Level of Signifi- cance
11 <sup>+</sup>	B	88	.750	1.043	.150	.140	1.013	n.s
	G	80	.600	.880				
13 <sup>+</sup>	B	105	.981	1.019	-.040	.147	.333	n.s
	G	100	1.030	1.007				
13 <sup>+</sup>	B	116	.957	1.130	-.007	.153	.046	n.s
	G	110	.964	1.165				
14 <sup>+</sup>	B	108	1.093	1.054	.366	.135	1.965	*
	G	104	.827	.900				
15 <sup>+</sup>	B	88	1.380	1.420	.373	.185	2.019	*
	G	87	1.207	.978				
Com- bined	B	505	1.063	1.163	.138	.072	1.881	n.s
	G	481	.931	1.032				

\* Significant at .05 level  
n.s Not significant.



effect of sex on classificatory ability disappears as the subjects attain the age of 14 years or above. However, for the combined groups of boys and girls, comprising all age levels, the performance of boys was found significantly better than the performance of girls.

The performance of boys and girls on the task of grouping of thought (G T) did not show significant difference at any age level as well as for the combined groups (vide Table 13).

The results presented in Table 14 show that the performance of boys on the task of generalization to arithmetical and algebraic symbols (GAA) was significantly better than the performance of girls at 12<sup>+</sup> and 15<sup>+</sup> age levels while there was no significant difference at 11<sup>+</sup>, 13<sup>+</sup> and 14<sup>+</sup> age levels. The performance of boys was significantly better than that of girls for the combined groups.

It is clear from the results presented in Table 15 that the performance of boys was significantly better than the performance of girls on the task of permutations and combinations and (P C) at all age levels as well as for the combined groups, except at age level 11<sup>+</sup> where no significant difference was found.

Regarding the performance of boys and girls on the task of ratio and proportion (RAP), no significant difference was found at the age levels 11<sup>+</sup> and 12<sup>+</sup> but at higher age levels,





i.e., 13<sup>+</sup>, 14<sup>+</sup> and 15<sup>+</sup> boys displayed significantly better performance than girls (vide Table 16). The performance of boys was found significantly better than girls for the combined groups as well.

In the light of the results presented in Table 17 it can be said that boys were found performing significantly better than girls, on the task of formulation of probing questions (PI), consistently at all age levels except the age level 13<sup>+</sup> where no significant difference was found. They also performed better in the case of the combined groups.

Regarding the performance of boys and girls on the task of interpretation and coordination of information (ICI), no significant difference was found either at any age level or for the combined groups (vide Table 18).

It is clear from the results presented in Table 19 that no significant difference between the performance of boys and girls on the task of stating and testing hypotheses (STI) was found at the age levels 11<sup>+</sup>, 12<sup>+</sup> and 13<sup>+</sup> while the performance of boys was found to be significantly better than that of girls at the age levels 14<sup>+</sup> and 15<sup>+</sup> as well as for the combined groups.

The performance of boys on the task of space visualisation (TV) was found to be significantly better than the performance of girls at all age levels and for the combined groups except at the age level 13<sup>+</sup> where no significant difference was found (vide Table 20).



The results presented in Table 21 demonstrate that no significant difference was found between the performance of boys and girls on the task of grasping the essence of the problem (21') at age levels 11<sup>+</sup>, 12<sup>+</sup> and 13<sup>+</sup> but the performance of boys was found to be significantly better than that of girls at age levels 14<sup>+</sup> and 15<sup>+</sup>. However, no significant difference was found between the performance of boys and girls for the combined groups.

TABLE 22

SIGNIFICANT DIFFERENCES BETWEEN THE PERFORMANCE OF BOYS AND GIRLS ON THE PIAGET TYPE TASKS WITH RESPECT TO THE LEVEL OF ABILITY AT WHICH THE SIGNIFICANT DIFFERENCES WERE FOUND

Age Level in Yrs.	Piaget Type Tasks									
	II	OCF	CA	IA	RA	TA	III	III	IV	CV
11 <sup>+</sup>	*	-	-	-	-	*	-	-	**	-
12 <sup>+</sup>	**	-	*	*	-	**	-	-	**	-
13 <sup>+</sup>	**	-	-	**	**	-	-	-	-	-
14 <sup>+</sup>	-	-	-	**	**	**	-	**	**	*
15 <sup>+</sup>	-	-	**	**	**	**	-	**	**	*
Combined	**	-	**	**	**	**	-	**	**	-

\* Significant at .05 level

\*\* Significant at .01 level

When the results of all the ten Piaget Type Tasks were viewed as a whole with respect to the comparative performance of boys and girls, the values of thirtyone t-ratios, out of the sixty t-ratios computed for the differences of performance



of boys and girls at five age levels, i.e., 11<sup>+</sup>, 12<sup>+</sup>, 13<sup>+</sup>, 14<sup>+</sup> and 15<sup>+</sup> years as well as for the combined group, were found to be significant (vide Table 22). In all the cases of the significant t-ratios, boys were having superior performance than girls. Thus, regarding the second hypothesis, it has been concluded that boys perform either equal to or better than girls on Piaget Type Tasks at respective age levels.

The third hypothesis, i.e., the measures of intelligence (both verbal and non-verbal) correlate significantly with the variables of adolescent thought, stands tested in the light of the results presented in Table 23. The values of 20 coefficients of correlation, computed between the measures of verbal intelligence and non-verbal intelligence on one side and the ten variables of adolescent thought on the other side were found to be ranging between .202 and .360 which were all significant at .01 level.

A close view of the results presented in Table 23 reveals that the five measures of academic achievement in Mathematics, Science, English, Punjabi and Hindi were found to be correlated significantly ( .01 level) with all the variables of adolescent thought except the variable of ratio and proportion (RAP), and the variable of space visualisation (V) was found to be correlated significantly only with the measure of academic achievement in Mathematics. Thus, out of the 50 coefficients of correlation, 40 coefficients of correlation were found to be significant at .01 level and one coefficient of correlation was significant at .05 level. On the basis of these results it has been concluded that there exists a



TABLE 21

COEFFICIENTS OF CORRELATION BETWEEN THE  
PERFORMANCE ON PIAGET TYPE TASKS  
AND OTHER VARIABLES

-----> PIAGET TYPE TASKS

OTHER VARS.	CL	GOT	GAA	PAC	RAP	FPO	ICI	STH	SV	GEP
IV	.385 ***	.456 ***	.538 ***	.535 ***	.389 **	.429 ***	.560 ***	.501 ***	.300 ***	.202 ***
INV	.403 ***	.416 ***	.520 ***	.462 ***	.287 ***	.323 ***	.487 ***	.267 ***	.334 ***	.235 ***
SR	.138 ***	.200 ***	.217 ***	.241 ***	.120 ***	.122 ***	.229 ***	.141 ***	.156 ***	.108 ***
RA	.202 ***	.367 ***	.417 ***	.454 ***	.318 ***	.362 ***	.435 ***	.426 ***	.257 ***	.128 ***
AAM	.154 ***	.093 ***	.187 ***	.141 ***	.057 ***	.136 ***	.159 ***	.104 ***	.094 ***	.110 ***
AAS	.147 ***	.117 ***	.190 ***	.150 ***	.039 ***	.170 ***	.146 ***	.143 ***	.056 ***	.111 ***
AAE	.096 ***	.121 ***	.149 ***	.131 ***	.048 ***	.138 ***	.134 ***	.132 ***	.059 ***	.094 ***
AAP	.091 ***	.152 ***	.152 ***	.103 ***	-.016 ***	.143 ***	.109 ***	.110 ***	.022 ***	.085 ***
AAH	.118 ***	.133 ***	.168 ***	.129 ***	.007 ***	.134 ***	.119 ***	.100 ***	-.002 ***	.075 ***
ADJ	.179 ***	.122 ***	.155 ***	.180 ***	.130 ***	.145 ***	.111 ***	.150 ***	.127 ***	.135 ***
A	.041 ***	.096 ***	.093 ***	.135 ***	.057 ***	.077 ***	.098 ***	.135 ***	.059 ***	.024 ***
B	.057 ***	.116 ***	.136 ***	.174 ***	.117 ***	.099 ***	.105 ***	.145 ***	.095 ***	.068 ***
C	.098 ***	.141 ***	.159 ***	.137 ***	.147 ***	.131 ***	.183 ***	.175 ***	.063 ***	.090 ***
D	-.021 ***	-.048 ***	-.101 ***	-.065 ***	-.020 ***	-.082 ***	-.070 ***	-.065 ***	-.023 ***	-.073 ***
E	-.083 ***	-.189 ***	-.132 ***	-.137 ***	-.020 ***	-.064 ***	-.123 ***	-.088 ***	-.021 ***	-.092 ***
F	.030 ***	.059 ***	.025 ***	.073 ***	.014 ***	.037 ***	.051 ***	.005 ***	.057 ***	-.003 ***
G	.148 ***	.163 ***	.218 ***	.232 ***	.140 ***	.152 ***	.213 ***	.177 ***	.124 ***	.072 ***
H	.096 ***	.185 ***	.169 ***	.209 ***	.129 ***	.102 ***	.154 ***	.172 ***	.043 ***	.056 ***
I	-.072 ***	.021 ***	.007 ***	-.004 ***	-.024 ***	.042 ***	.039 ***	.055 ***	-.074 ***	-.041 ***
J	.009 ***	-.048 ***	-.025 ***	-.002 ***	-.012 ***	.030 ***	-.028 ***	-.008 ***	-.007 ***	-.069 ***
O <sub>1</sub>	-.082 ***	-.176 ***	-.185 ***	-.183 ***	-.063 ***	-.170 ***	-.177 ***	-.181 ***	-.067 ***	-.096 ***
Q <sub>2</sub>	.018 ***	.048 ***	.056 ***	.032 ***	.083 ***	.053 ***	.088 ***	.084 ***	.052 ***	.018 ***
Q <sub>3</sub>	.097 ***	.180 ***	.206 ***	.178 ***	.099 ***	.171 ***	.204 ***	.167 ***	.070 ***	.086 ***
Q <sub>4</sub>	-.139 ***	-.180 ***	-.183 ***	-.163 ***	-.105 ***	-.130 ***	-.129 ***	-.135 ***	-.067 ***	-.104 ***

\*\*\* Significant at .05 level

\*\* Significant at .01 level





significant relationship between the measures of academic achievement and the variables of adolescent thought which leads to the confirmation of the fourth hypothesis.

It is evident from the results presented in Table 33 that the coefficients of correlation computed between the measures of reasoning ability (RI) and space relations (SR) on the one hand and the measures of adolescent thought on the other hand were all significant at .01 level and were found to be ranging between .103 and .454. Thus, the fifth hypothesis, i.e., the measures of reasoning ability and space relations yield significant correlations with the various measures of adolescent thought, has been empirically verified.

All the coefficients of correlation between the measure of adjustment (ADJ) and the variables of adolescent thought were found to be significant at .01 level and their values were ranging between .111 and .180 (vide Table 33). It has been concluded that the measure of adjustment is significantly related to the variables of adolescent thought. The sixth hypothesis, thus, stands tested.

The seventh hypothesis, i.e., the measures of different traits of personality exhibit significant correlations with measures of the dimensions of adolescent thought, has been confirmed partially as some of the personality traits exhibited a consistent picture of correlations with all the measures of the dimensions of adolescent thought while the others were found to be correlated only with the measures of some specific dimensions of adolescent thought (vide Table 33). Thus, all the measures of



the fourteen traits of personality cannot be taken as correlates of each and every dimension of adolescent thought because the position of the correlates has been found to be changing from one dimension to the other. The description of the correlations of the personality traits\* with the dimensions of adolescent thought have been given below with reference to the results presented in Table 23.

i) The reserved-outgoing (1) trait of personality was found to be having positive correlation with the dimensions of adolescent thought : grouping of thoughts (VII), generalisations to arithmetical and algebraic symbols (XII), permutations and combinations (XIII), interpretation and coordination of information (IX), stating and testing hypotheses (XI), which were significant at .01 level and with the dimension of formulation of probing questions (XIV) which was significant at .05 level.

ii) The concrete-abstract thinking (2) trait of personality showed consistently positive correlation with all the dimensions of adolescent thought except the dimension of classification (XV). All the coefficients of correlation were found to be significant at .01 level leaving aside the case of the dimension of grasping the essence of the problem (XIII) where it was significant at .05 level.

iii) The trait of emotional instability - stability (3) also showed positive correlation with all the ten dimensions of adolescent thought. The coefficients of correlation were all significant at .01 level except that with the dimension of space visualization (XVI) which was significant at .05 level.

---

\* Low-High scores



iv) The phlegmatic-excitabile (P) trait of personality was found having negative correlation with all the measures of the dimensions of adolescent thought, however, all the coefficients are not significant. The coefficients of correlation between the phlegmatic-excitabile trait and the dimensions of generalization to arithmetical and algebraic symbols (GAS) and formulation of probing equations (FPE) were found to be significant at .01 level and those of the dimensions of permutations and combinations (PAC), interpretation and coordination of information (ICI), stating and testing hypotheses (STH) and grasping the essence of the problem (GEP) were significant at .05 level.

v) The obedient - asserive trait (A) also showed a trend of negative relationship with all the dimensions of adolescent thought. The dimensions of classification (CL), grouping of thought (GOT), generalization to arithmetical and algebraic symbols (GAS), permutations and combinations (PAC), interpretation and coordination of information (ICI), stating and testing hypotheses (STH) and grasping the essence of the problem (GEP) were found to be having negative correlations significant at .01 level while the dimension of formulation of probing questions (FPQ) was having a negative correlation significant at .05 level.

vi) No significant correlation was found between the serious-headedless (F) trait of personality and the dimensions of adolescent thought except that of the dimension of permutations and combinations (PAC) which was having positive correlation significant at .05 level.



vii) The expedient-conscientious (C) trait of personality showed consistently positive correlation with all the dimensions of adolescent thought. All the coefficients of correlation were significant at .01 level except the one that of the dimension of grasping the essence of the problem (G2) which was significant at .05 level.

viii) The shy-adventurous (I) trait of personality was also found to be having consistently positive correlation with all the dimensions of adolescent thought except the two, those of space visualization (V) and grasping the essence of the problem (G2). All the above mentioned coefficients of correlation were significant at .01 level.

ix) The toughminded-tenderminded (J) trait of personality did not exhibit significant relationship with the measures of the dimensions of adolescent thought except in the case of two dimensions, i.e., classification (C5) and space visualization (V). The coefficients of correlation of these two dimensions were negative and significant at .05 level.

x) The zealous-circumspect (J) trait of personality was found to be having a significant correlation with only one dimension of adolescent thought, i.e., grasping the essence of the problem (G2). The coefficient of correlation was negative and significant at .05 level.

xi) The secure-insecure (I) trait of personality showed consistently negative correlation with all the dimensions of the





adolescent thought. All the coefficients of correlation were significant at .01 level except in the case of the dimensions of ratio and proportion (RP) and space visualization (V) which were significant at .05 level.

xii) The group dependent - self sufficient ( $\eta_2$ ) trait of personality did not show any correlation with the dimensions of adolescent thought except in the case of ratio and proportion (RP), interpretation and coordination of information (ICI) and stating and testing hypotheses (TH). The coefficients of correlation were found to be positive and significant at .01 level.

xiii) The uncontrolled-self disciplined ( $\eta_3$ ) trait of personality was found to be having consistently positive relationship with the measures of all the dimensions of adolescent thought. All the coefficients of correlation were significant at .01 level except one that of the space visualization (V) which was significant at .05 level.

xiv) The relaxed-tense ( $\eta_4$ ) trait of personality showed negative relationship with the measures of all the dimensions of adolescent thought. All the coefficients of correlation were found to be significant at .01 level except in the case of space visualization (V) which was significant at .05 level.



### Interpretations and Discussion

It may be recalled that the exploration of the relationship of the development of the different dimensions of adolescent thought with the variables of age, sex, intelligence, academic achievement, reasoning ability, space relations, adjustment and other personality traits, and the determination of the structural structure of adolescent thought, were the major objectives of this study.

The results of the study show that the development of the various dimensions of adolescent thought is contingent upon the age during the formal-operational period (vide Table 10). There is a clear evidence of a regular growth of the various dimensions of adolescent thought through 11<sup>+</sup>, 12<sup>+</sup>, 13<sup>+</sup>, 14<sup>+</sup> and 15<sup>+</sup> years of age. However, in the case of the dimensions of ratio and proportion (14), space visualization (V) and grasping the essence of the problem (66) a dip has been noticed in the process of the growth of these dimensions (Fig. 8), which may be characterized as the transitional period in the settlement of the new strategies and concepts in the minds of the adolescents (Gaiya and Pandey, 1979). The relationship of the development of adolescent thought with the age does not need a special explanation as it is well understood that as the age increases, the experiences of the adolescents accumulate, and increase the chances to reach a state of equilibration through the processes of assimilation and accommodation carried out from time to time. The incompleteness of the development of the dimensions of adolescent thought even upto the age of 15<sup>+</sup> years



indicates the under-functioning of the adolescents at formal level and thus the possibility of the extension of the development period to a higher age level.

The performance of boys and girls on Piaget's type tasks at respective levels as well as for the combined groups, and in no case girls have a mean better performance than boys (Table 23, 24 and 25). It is very difficult to say whether the superiority of the boys over the girls with respect to their performance on Piaget's type tasks is genetic. However, it can be explained well on the basis of social and cultural set up from which the sample has been drawn. In the rural culture of Punjab, girls do not get sufficient opportunities, particularly, during adolescence to interact with the world both scientific and social. They usually remain restricted to a sort of domestic environment. Thus, the development of formal thought, which takes place only through an interaction with a nexus of supportive and stimulating factors in the environment, is hindered in the case of the girls.

The development of the various dimensions of adolescent thought has been found to be co-axial with the measures of intelligence both verbal and non-verbal, reasoning ability and space relations (vide Table 23) which may be described as the allied abilities. The adjustment of an individual also plays a significant role in the development of adolescent thought. If viewed psychologically it seems quite meaningful as adjustment is indispensable for mental health which ensures maximum



effectiveness of mental abilities. A well adjusted individual brings out a balance among his intellectual, emotional and physiological satisfactions. Moreover, he has a clear insight into his own abilities and limitations. Thus, a well adjusted individual lives an orderly life in which the necessary functions of living are so regularized that a good deal of energy is made available for the organization of the functioning of the various aspects of cognitive, affective and social life of the individual. As a result he marches forward toward the actualization of his potential. The measures of the academic achievement in the school subjects, such as, Mathematics, Science, English, Punjabi and Hindi have been found to be having significant bearings on the development of adolescent thought. As the contents of the subjects like Mathematics and Science are very much in harmony with and provide good exercise for the development of the various dimensions of adolescent thought, and the languages like English, Punjabi and Hindi serve as vehicles of thought, the students having got mastery over these subjects do come across a lot of manipulative and imaginative type of experiences which are the necessary and desirable pre-requisites of the development of adolescent thought. Moreover, the various concepts developed among the students during the studies of these subjects may also be helpful in the development of adolescent thought.

The personality traits investigated in the present research fall into the category of the structural factors of personality which comprise temperamental qualities, constitutional predisposition and basic behavioural patterns. These factors





are biologically based and constitutionally determined and as such, they are relatively stable and lasting characteristics of personality (Chalival, 1977). Ten factors of personality, out of the fourteen factors of personality studied (BTF), are found to be correlated significantly with six or more than six dimensions of the ten variables of adolescent thought investigated. Thus, the traits like outgoing tendencies, abstract thinking, emotional stability, phlegm, obedience, conscientiousness, adventurousness, feeling of security, self-discipline and relaxation correspond with the development of adolescent thought. The examination of these traits of personality reveals that they are not quite independent of each other, rather they are liable to be grouped together into certain clusters of functionally related traits. Thus, the ten traits of personality related with the development of adolescent thought may be grouped into two main categories. The first category consisting of emotional stability, phlegm, obedience, feeling of security, self-discipline and relaxation traits, corresponds to a specific type of personality temperament of an individual who is prone to be serious-minded, calm, cool, contented, disciplined and obedient. This type of person conserves his energy and puts it in the direction he desires. The second category, including traits of outgoing-tendencies, adventurousness, conscientiousness and abstract thinking, is associated with a specific type of behaviour. The person having this sort of personality is self-initiating, believes in adventurous activities and has markedly developed abstract thinking. Thus, the energy conserved by him at one stage is utilized for the activities which germinate the development of adolescent thought.



## CHAPTER VI

Analysis of Mathematical Structure  
Underlying the Adolescent Thought



## CHAPTER VI

Analysis of Mathematical Structure  
Underlying the Adolescent Thought

## Introduction

Factor analysis, like all other statistics, is a branch of applied mathematics which is used largely as a tool to provide a mathematical model to explain the underlying behaviour of the data (Lawson, 1960). It involves the analysis of a large battery of tests in order to identify a few common factors. Thus, the tests which best measure these factors may be considered direct measures of the 'factors of mind.' The principal concern of factor analysis, therefore, is the resolution of a set of variables linearly in terms of a small number of factors. Secondly, the individual factor loadings of the various tests included in a battery on the factors provide mathematical information about the behavioural composition of the tests and are, thus, the source of direct and concrete evidence of the tests' validity.

It has been accepted by now that a given matrix of correlations can be factorized in a number of ways. Thus the choice of a method out of the large number of equally accurate methods available, rests with the investigator which can wisely be made keeping in view statistical simplicity and psychological meaningfulness of the factor solution. A statistically sound approach would be to represent the original set of variables in terms of a small number of factors, determined in sequence so



that at each successive stage the factor would account for a maximum of the variance. This type of solution is possible by the Principal Axes Method of factor analysis which has been employed in the present study.

#### Some Background Studies

Abramowitz (1975) conducted a study on a group of 33 seventh grade students of 12-13 years. A revised version of Warplus's proportionality test organized into test booklets containing six tasks was administered to the subjects in group settings. All the tests that had to do with the handling of fractions were loaded on factor I which accounted for 33.7% of the variance; the average proportionality score and ability were loaded on factor II which accounted for 36.6% of the variance; the size contrast, the ratio contrast and correlative test of inverse relations were loaded on factor III which accounted for 19.7 % of the variance. This depicted the nature of the components of proportional thought as the skill tests of facility with fractions load on a different factor than tasks involving proportionality.

Bart (1971) administered four tasks of formal operations: Pendulum Task, Conservation of Motion on a Horizontal Plane, Equilibrium in the Balance and Projection of Shadows, to a group of 90 students of above average scholastic ability and belonging to three age levels of 13, 16 and 19 years. Also a test of verbal intelligence and the tests of formal reasoning in biology, history and literature were given. Factor analysis of these





eight measures was done. The eight measures were found to be having bi-factor structure with a large substantial first factor of formal operations and a second factor related to content which distinguished tasks from tests. Formal thought was found to have a substantial verbal intelligence component as well as non-verbal intelligence component.

Judek, et al (1967) reported an inter task consistency of Piaget's levels representing a general Piagetian factor independent of any general intelligence factor entering into the Binet scale.

Guerin (1975) administered Piaget's test of logical operations to 896 students from four different environments to get the measures of attainment of seven logical operations - classification, seriation, multiplication, compensation, proportional thinking, probability and correlational thinking - to associate with the final two stages of Piaget's cognitive development. The structure of the logical operations described above consisted of two correlated factors, i.e., the concrete operational factor and the concrete and logical factor. The logical operation of compensation was related to both factors and represented a transition operation between the purely concrete operations and the purely formal operations.

Whitney (1975) found that Piagetian measures bore a modest positive degree of relationship to performance on traditional measures of intelligence, and thus, clarified that the two types of measures were neither totally distinct nor totally



identical. Both the measures were found to be contributing to a general intelligence factor. It also found that Piagetian factors were having a dominant concurrent association with the measures of school achievement, thus, pointed out the way to new and possibly more reliable and valid predictors of achievement.

Joyell and Lutterworth (1966) found a "central intellectual ability" underlying the performance on the tests of proportionality using the Principal Component Analysis.

Stephens, et al (1969) reported significant correlations of /100 verbal IQ, performance IQ and a full scale IQ with Piagetian tasks of reasoning and formal operations administered to the subjects of 6 to 18 years age. They have identified a general intelligence factor when the data were put to factor analysis. The fact that the Piagetian measures were covered by three factors, supported the notion of a multidimensional structure of intelligence in the Piagetian assessed areas as in the other traditional areas.

Vaidya (1975) investigating the growth of logical thinking during adolescence using seventeen problems and also the measures of intelligence, adjustment and immediate test reaction inventory, etc., on a sample of 200 students of grade VI to X found that unexpectedly the factor loading of intelligence on the first factor was insignificant. In all, the following ten factors were extracted:

1. Schematic Learning General
2. Adjustment
3. Problem Orientation



4. Sensing Problems
5. Symbolisation
6. Testing Hypotheses
7. Using Constant Differences
8. Aspect Character
9. Seeing the problem as a whole
10. Intelligence

Weeks (1973) administered three tests : Piaget's test of conservation of volume, Peel's story test to measure logical reasoning and Helmark's test of the understanding of correlation and the ability to use combinatorial analysis, to a sample of 190 seventh graders, 195 eighth graders and 175 ninth graders to measure the development of formal operations. Factor analysis yielded factors that could be reliably classified as either formal operations or verbal reasoning or numerical ability. The loadings of the items indicated a surprising mutual exclusivity of formal operations and verbal reasoning as operationally defined by the tests.

The background studies discussed above show that very few have taken sample of more than 200 subjects and have handled more than ten variables. Thus the attempts made by the various research workers were handicapped either from the sample viewpoint or with respect to the comprehensiveness of the study or both.

### The Present Study

The major objective of this investigation was to make a comprehensive study of the mathematical structure of adolescent thought using ten Piaget Type Tasks and also taking the measures of the other variables such as intelligence (verbal and non-verbal), reasoning ability, space relations, academic









Considering the half matrix of intercorrelations of the ten Piaget Type Tasks presented in Table 24, it was found that all the 45 coefficients of correlation were positive and significant at .01 level. This showed that the performances on ten Piaget Type Tasks formed an interrelated measures of adolescent thought. The factorial structure was determined subjecting the above correlation matrix to factor analysis by Principal Axes Method. Results regarding the factorial structure of the tasks are presented in Table 25.

TABLE 25

ORIGINAL PRINCIPAL MATRIX OF TEN TASKS FACTOR LOADING OF PIAGET TYPE TASKS ON THE ONLY SIGNIFICANT FACTOR DETERMINED

T.No.	Task	Factor I
1	IL	.600
2	COF	.653
3	GAI	.755
4	FAC	.726
5	RIF	.465
6	PPV	.668
7	ICI	.705
8	T.I	.659
9	IV	.674
10	GL	.405
Sum of Squares		3.981
% of Total Variance		39.8
% of Common Variance		100.0



The results presented in Table 23 clearly demonstrate the unifactor structure of the measures of Piaget Type Tasks as only a single significant factor (having eigen value  $>1$ ) could have been extracted through factor analysis. This single factor accounts for 39.8% of the total variance which indicates the uni-dimensionality of the formal thought running through all the tasks. The factor may be named, very conveniently, as Factor of Formal Thought. Since there is only one factor, rotation makes no sense. Secondly, the factor loadings of the various Piaget Type Tasks on the Factor I (only factor) may be taken as the indices of the factorial validity of the respective tasks which are all quite significant and high (ranging from .405 to .753). Thus, the eighth hypothesis stands verified and proved as the performances on Piaget Type Tasks form an inter-related measure of adolescent thought and exhibit a unifactor structure.

The ninth hypothesis of this study was stated as : the measures of intelligence, academic achievement, reasoning ability, space relations, adjustment and personality traits cluster in specific constellations with the measures of the dimensions of adolescent thought, explaining thereby the common factor variance. To test this hypothesis the data regarding all the 34 measures included in this study were put to factor analysis using Principal Axes Method. The various steps undertaken in this regard are described ahead. As mentioned earlier, thirty-four variables of different abilities with respect to each subject were investigated in the present study. The various



measures, in the same serial order as employed in the correlation matrix, are described below:

1. Intelligence verbal;
2. Intelligence non-verbal
3. Adjustment
- 4-17. Fourteen traits of personality (EPQ)
18. Space relations
19. Reasoning ability
- 20-29. Ten Measures of Piaget Type Tasks.
- 30-34. Academic achievement in five school subjects.

#### Correlation Matrix

A correlation matrix (34 x 34) presented in Table 25 was obtained using the above mentioned 34 measures for the whole sample (N=226) of the study. Considering the half correlation matrix, divided symmetrically by the diagonal, it was found on physical counting that it contained 561 coefficients of correlation out of which 426 were positive and the remaining 135 were negative. Out of the 426 positive coefficients of correlation 292 were found to be significant at .01 level, 317 significant at .05 level and 109 insignificant. Out of the 135 negative coefficients of correlation 53 were found to be significant at .01 level, 75 significant at .05 level and 60 insignificant. The magnitudes of the coefficients of correlation, irrespective of the signs, were found ranging from .001 to .597.

#### Obtaining the Factors

The correlation matrix (34 x 34) discussed above was subjected to factor analysis using the Principal Axes Method. Eight significant factors, having eigen values greater than one,



TABLE 26  
CORRELATION MATRIX (34 x 34)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	
1 IV																																			
2 INV	523	196	171	256	221	100	181	098	296	281	042	043	504	099	314	201	200	597	384	456	538	535	389	429	560	501	304	203	166	153	195	153	215		
3 ADJ																																			
4 A																																			
5 B																																			
6 C																																			
7 D																																			
8 E																																			
9 F																																			
10 G																																			
11 H																																			
12 I																																			
13 J																																			
14 Q																																			
15 Q2																																			
16 Q3																																			
17 Q4																																			
18 SR																																			
19 RA																																			
20 CL																																			
21 GOT																																			
22 GAA																																			
23 PAC																																			
24 COR																																			
25 FPO																																			
26 IC1																																			
27 ITH																																			
28 SV																																			
29 GER																																			
30 AM																																			
31 AAS																																			
32 AAE																																			
33 AAF																																			
34 AAH																																			

N.B THE VALUES ARE GIVEN WITHOUT DECIMAL POINTS





were extracted and retained for Varimax Rotation. All the computations were done through "ELITE - 1022 Computer" at Comptronics India, New Delhi, using 11-1 programme of factor analysis given in Statistical Package for the Social Sciences (SPSS). Results regarding the factor loadings of the 34 variables included in this study on the 8 significant factors are presented both in the case of Original Factors as well as Varimax Rotated Factors in Tables 27 and 28 respectively.

It is evident from the results presented in Table 27 that, in the case of Original Factors, the accumulated percentage of the total variance accounted for by the factors I through VIII has been found to be ranging from 19.3 to 49.1 while the percentage of common variance accounted for by the same factors is ranging from 39.3 to 100. The results presented in Table 28 clearly demonstrate that the accumulated percentage of the total variance accounted for by the factors I through VIII, in the case of Varimax Rotated Factors, has been ranging from 15.4 to 49.0 and the accumulated percentage of common variance accounted for by these factors range from 31.5 to 100.0.

#### Interpretation of Factors

Before presenting data for the interpretation of the factors, it is necessary to simplify the apparent factorial complexity regarding the various variables included in the study by ignoring the small sizes of the different factor loadings for pinpointing the attention on the significant factor loadings only whose substantial contributions could be



TABLE-27

137

# ORIGINAL FACTOR MATRIX

## FACTORS →

S NO	Variable	1	2	3	4	5	6	7	8	h <sup>2</sup>	1-h <sup>2</sup>
1	IV	-795	125	061	067	-201	024	041	092	706	294
2	INV	-690	100	-124	074	020	004	078	-136	532	468
3	ADJ	-309	046	031	-279	361	-095	156	-043	342	658
4	A	-224	061	385	-212	084	-010	136	150	295	705
5	B	-274	052	300	005	-264	-289	282	016	399	601
6	C	-307	126	472	-215	276	134	-111	-074	491	509
7	D	121	-026	119	459	-468	-233	125	-066	534	466
8	E	234	057	129	285	400	-172	-123	487	598	402
9	F	-114	-002	387	072	-094	-342	-094	-341	419	581
10	G	-376	076	371	-237	-035	-117	-093	105	376	624
11	H	-340	084	463	-273	082	072	168	-010	471	529
12	I	-003	-003	300	251	033	659	223	-116	648	352
13	J	041	015	239	347	162	-134	183	049	260	740
14	Q <sub>1</sub>	300	047	293	392	318	-154	173	-071	489	511
15	Q <sub>2</sub>	-101	121	351	217	-059	177	-563	-085	554	446
16	Q <sub>3</sub>	-350	067	426	-064	-156	-111	-252	-079	418	582
17	Q <sub>4</sub>	302	-022	167	584	091	188	038	-124	521	479
18	SR	-320	075	-102	-006	222	-017	448	-267	440	560
19	RA	-662	106	-054	052	-177	-046	150	222	560	440
20	CL	-544	077	-211	154	183	-172	-100	-158	467	533
21	GOT	-616	103	-100	019	-119	121	013	-228	482	518
22	GAA	-718	090	-133	101	036	058	-042	705	558	442
23	PAC	-695	149	-080	090	-012	-025	095	071	535	465
24	COR	-433	225	-010	088	007	-018	001	254	311	689
25	FPS	-596	066	-119	175	108	046	-142	154	463	537
26	ICI	680	135	-072	125	-074	168	-002	-047	537	463
27	STH	-623	134	-031	100	-041	199	-021	264	528	472
28	SV	-447	182	-181	229	219	-302	-124	-027	473	527
29	GEP	-337	014	-186	-030	240	-061	-239	-392	435	565
30	AAM	-347	-586	015	026	104	-034	040	-043	480	520
31	AAS	-335	-643	-017	041	081	100	-035	051	547	453
32	AAE	-332	-701	047	048	-020	005	-077	072	618	382
33	AAP	-305	-711	064	030	054	-044	033	014	609	391
34	AAH	-326	-680	077	008	-063	-051	-006	022	582	418
Sum of squares		6.550	2.492	1.786	1.504	1.164	1.116	1.060	1.004	16.676	17.324
% Total variance		19.3	7.3	5.3	4.4	3.4	3.3	3.1	3.0	49.1	50.9
% Common variance		39.3	14.9	10.7	9.0	7.0	6.7	6.4	6.0	100%	

12-12  
V-58

ALL DECIMALS HAVE BEEN OMITTED IN FACTOR LOADINGS



TABLE 28  
VARIMAX ROTATED FACTOR MATRICES  
FACTORS ---->

S.NO.	Variable	1	2	3	4	5	6	7	8	9	10
1	IV	758	126	243	-134	181	332	-005	024	717	200
2	XIV	635	107	101	-175	073	043	263	-140	517	307
3	ADJ	153	053	357	012	-177	-117	316	-304	310	084
4	A	097	031	514	050	015	001	-122	-058	216	704
5	B	194	037	256	038	454	-084	-123	-445	400	300
6	C	110	002	622	045	-124	-134	197		490	310
7	D	-003	-010	-276	170	623	058	-164		534	717
8	E	-061	-057	-007	025	-271	-236	-210		590	310
9	F	-063	047	251	068	469	-066	306	146	510	587
10	G	212	054	523	-073	102	-144	-016	130	370	674
11	H	136	038	649	-032	064	122	-006	-080	470	530
12	I	036	018	099	107	-065	760	107	033	648	352
13	J	012	012	046	473	155	080	-015	-034	258	717
14	O <sub>1</sub>	-233	-089	015	521	116	128	386	-056	468	510
15	O <sub>2</sub>	095	-080	135	064	038	160	166	680		
16	O <sub>3</sub>	101	060	013	-070	268	-046	117	335		
17	O <sub>4</sub>	-152	-038	-254	462	102	424	023	160		
18	SR	247	011	102	044	044	174	260	-519	532	
19	RA	684	102	141	-093	135	-079	-133	-106	500	
20	CL	513	095	-030	047	-002	-140	415	-055	468	532
21	GOT	649	069	083	-259	114	149	255	-045	482	510
22	GAA	609	135	089	-065	-032	011	186	-013	359	441
23	PAC	697	074	141	-038	060	-030	082	-109	535	460
24	PAP	617	064	129	064	-033	-041	-090	-026	310	690
25	FPC	552	157	037	049	-131	-032	103	101	461	539
26	ICA	677	075	091	-137	040	157	139	015	537	463
27	STH	682	076	140	-053	-103	072	-114	074	528	472
28	SV	493	018	-047	206	008	-268	337	-009	473	527
29	GEP	225	083	002	-112	-099	-055	593	020	435	565
30	AAM	115	666	052	-003	004	003	114	-089	480	520
31	AAS	130	718	001	-033	-098	054	024	004	547	453
32	AAE	104	774	016	-041	015	-015	016	072	616	362
33	AAP	049	774	050	010	034	-008	030	-051	609	391
34	AAH	076	747	054	-067	102	-026	-009	007	582	418
Sum of squares		5248	2863	2159	1495	1247	1110	1306	1173	16661	17339
% Total variance		15.4	8.4	6.4	4.4	3.7	3.4	3.8	3.5	49.0	51.0
% Common variance		31.5	17.2	13.0	9.0	7.6	7.0	7.8	7.0	100.0	

ALL DECIMALS HAVE BEEN OMITTED IN FACTOR LOADINGS

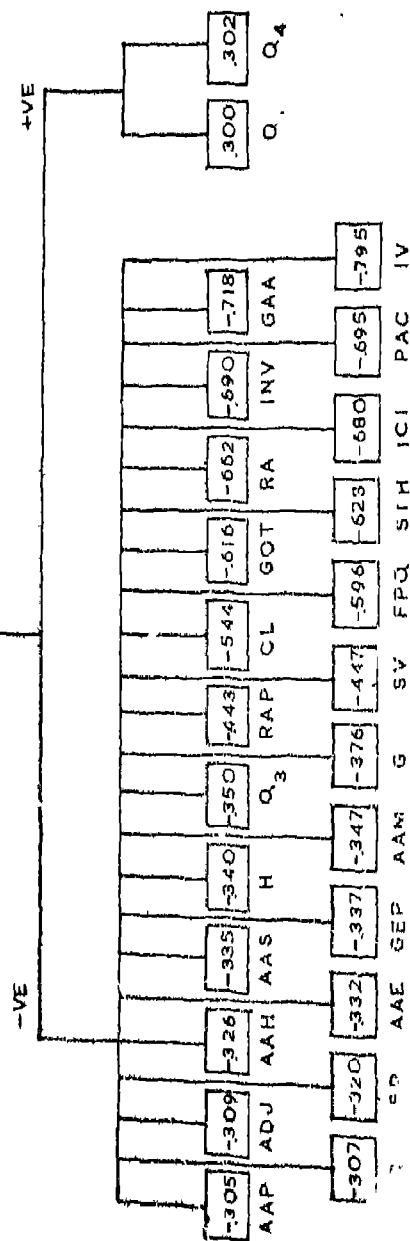
All loadings below  $\pm .30$  have not been shown



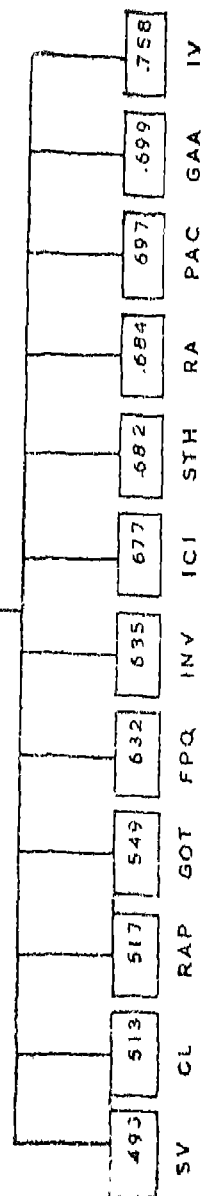


FIG- 9

# ORIGINAL FACTOR I SIGNIFICANT LOADINGS



# VARIMAX FACTOR I SIGNIFICANT LOADINGS





considered for the determination of the nature of the factors. In practice there is no uniform criterion for judging how much small is small. Benjamin Fruchter (1967) has suggested that values of factor loadings less than .20 are, generally speaking, insignificant and hence can be ignored. Anderson and Eaton have ignored values upto .30 for the purpose of factorial interpretations (Vaidya, 1975). In the present study also the factor loadings of the different variables on the various factors having values numerically less than .300 have been ignored while interpreting the factors.

#### Factor I

Significant loadings of the different variables on Factor I (both Original and Varimax Rotated) have been shown in Fig. 9. A minute inspection of the figure shows that, in the case of Original Factor I, 26 variables are having significant loadings on this factor. This factor seems to be bi-polar in nature as the factor loadings of 24 variables - ten variables of the dimensions of adolescent thought (CL, COT, CAA, P12, RAP, FPQ, ICI, CTI, CV and CSP), five variables of academic achievement (AAH, AAG, AAE, AAP and AAM), two variables of intelligence (IV, IW), a variable of reasoning ability (RA), a variable of space relations (RI), a variable of adjustment (ADN) and four variables of personality traits, (C, G, I, and Q3) - have been found to be negative and thus, they lie on the negative pole. The range of the significant loadings has been varying from -.305 to -.798. The highest loading being that of the variable of verbal intelligence. Other variables are given



in the ascending order starting from III (-.305) and ending up with IV (-.795). The variables of two personality traits ( $Q_1$ ,  $Q_4$ ) lie on the positive pole having factor loadings .301 and .302 respectively. This illusionary bi-polarity is only due to the reverse direction of scoring of the  $Q_1$  and  $Q_4$  traits of personality.

It is quite clear that this factor has brought together the variables of adolescent thought, academic achievement, intelligence, reasoning ability, space relations, adjustment and some of the personality traits on one continuum (constellation) as it is running through all the variables. It accounts for 39.3 % of the common factor variance and 19.3 % of the total variance (vide Table 27).

Varimax rotated Factor I provides a very simple structure. Twelve variables are found to be having positive loadings on this factor which include nine measures of the dimensions of adolescent thought (CV, TL, HAW, GGT, PPQ, ICI, STI, PII, QII), two variables of intelligence (IN, IV) and a variable of reasoning ability (RA). The loadings have been found to be varying from .403 to .758. The highest factor loading has been shared by the variable of verbal intelligence. The other variables are presented in the ascending order, starting with CV (.403) and ending with IV (.758). This factor has brought together the measures of dimensions of adolescent thought, reasoning ability and intelligence. It accounts for 31.5 % of the common factor variance and 15.4% of the total variance (vide Table 28). On the basis of the nature of the loadings of





ORIGINAL FACTOR  
CONCENTRATION LOADINGS

535	-643	-580	-70
AAW	AAW	AAW	AAW

[illegible]

666	718	747	774	804
AAH	AAS	AAH	AAE	AAH

the various variables in the case of the Varimax Rotated Factor I, it can be named as General Intellectual Factor of Adolescent Thought.

## Factor II

Only the variables of academic achievement in school subjects (AM, AT, AI, AS, AP) are having significant loadings on Factor II, both in the case of Original Factor as well as Varimax Rotated Factor. The factor loadings of the measures of academic achievement on Original Factor II are negative and ranging from  $-.586$  to  $-.711$ . The measures of academic achievement put in the ascending order with respect to the size of factor loadings as presented in Fig. 10 are AM ( $-.586$ ), AT ( $-.643$ ), AI ( $-.680$ ), AS ( $-.701$ ) and AP ( $-.711$ ). This factor accounts for 14.9 % of the common factor variance and 7.3 % of the total variance (vide Table 27).

In the case of Varimax Rotated Factor II, the signs of the factor loadings become positive though the variables with significant loadings on this factor remain the same as in the case of Original factor. The range of the various factor loadings has been found to be varying from  $.666$  to  $.774$ . The ascending order of the different variables with respect to the size of the factor loadings is AM ( $.666$ ), AT ( $.718$ ), AI ( $.747$ ), AS ( $.774$ ) and AP ( $.774$ ). This factor accounts for 17.2 % of common factor variance and 8.4 % of total variance (vide Table 28). Since all the measures of academic achievement are having loadings almost of equal magnitude on Varimax Rotated Factor II, it has been







11

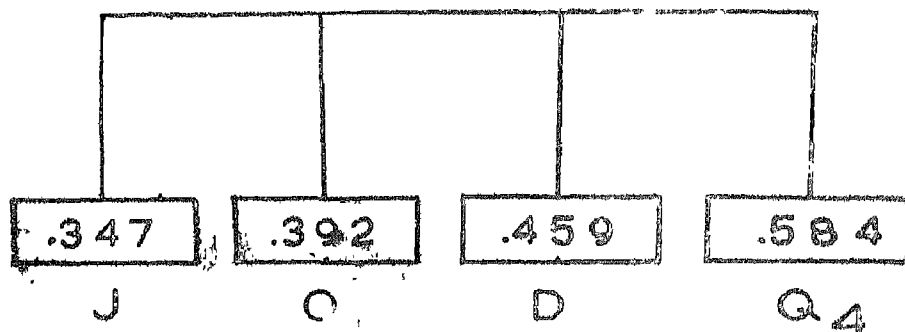
[illegible][illegible][illegible]

357	410	414	406	408	409
AD	AD	AD	AD	AD	AD

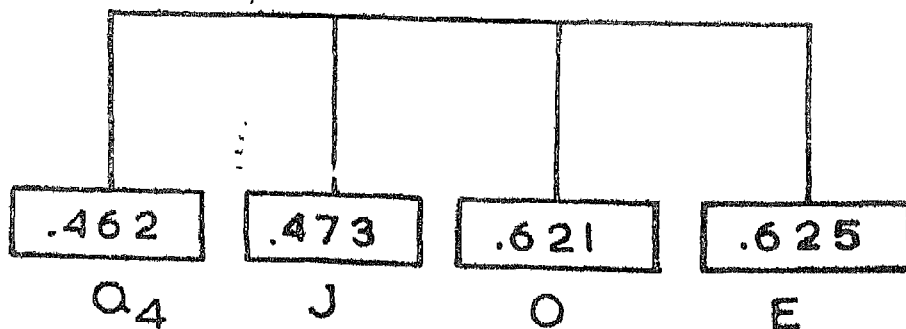


FIG.- 12

ORIGINAL FACTOR IV  
SIGNIFICANT LOADINGS



VARIMAX FACTOR IV  
SIGNIFICANT LOADINGS



named as Factor of Academic Achievement instead of naming this factor on the basis of a single measure of academic achievement.

#### Factor III

The results presented in Fig. 11 demonstrate that the measures of personality traits  $X_1, I_1, I_2, O_1, P_1, I_3, C$  and  $I$  have significant positive factor loadings on Original Factor III. The highest loading being that of  $I$  (.483) and the lowest of  $X$  (.307). The loadings of the other traits are in the same order as they are given above. This factor accounts for 10.7 % of common factor variance and 5.3 % of total variance (vide Table 27).

In the case of Varimax Rotated Factor III only the measures of  $X$  (.357),  $I_3$  (.418),  $I$  (.516),  $O$  (.523),  $C$  (.622) and  $P$  (.649) have significant loadings. It accounts for 13.0 % of common factor variance and 6.4 % of total variance (vide Table 28). This is clearly a group factor of personality. On the basis of the nature of the various traits of personality having significant factor loadings on Varimax Rotated Factor III, it can be named as Adjustment Factor.

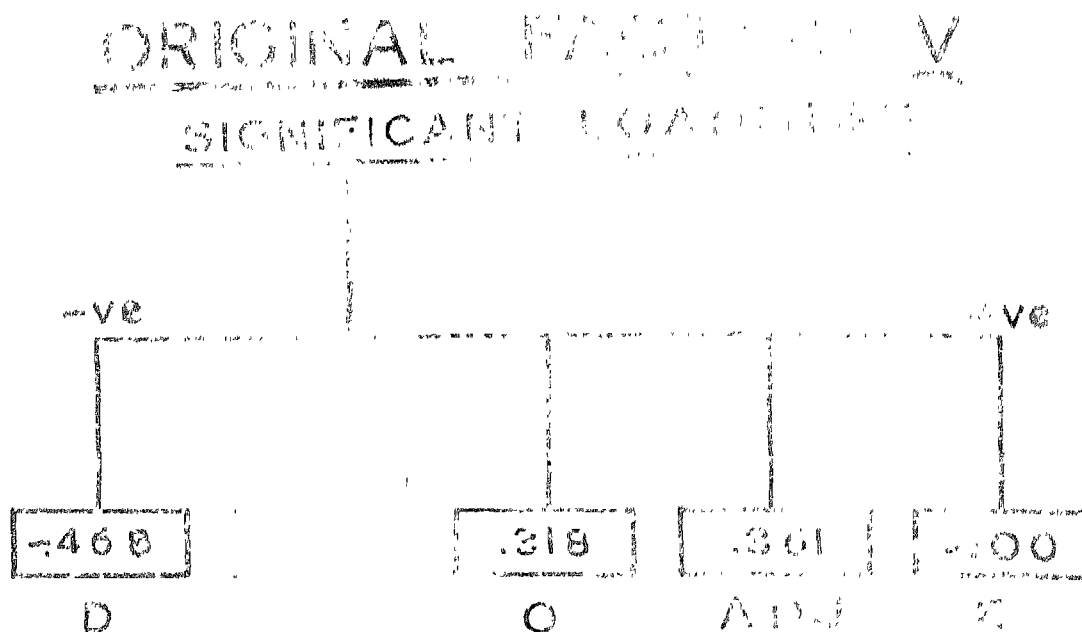
#### Factor IV

The factor loadings of personality traits  $X, O, D$  and  $I_4$  are found to be significant on Original Factor IV (Fig. 12). The order of the size of the loadings is  $O$  (.347),  $I$  (.352),  $D$  (.459) and  $X$  (.564). This factor accounts for 9.0 % of common factor variance and 4.4 % of total variance (vide Table 27).

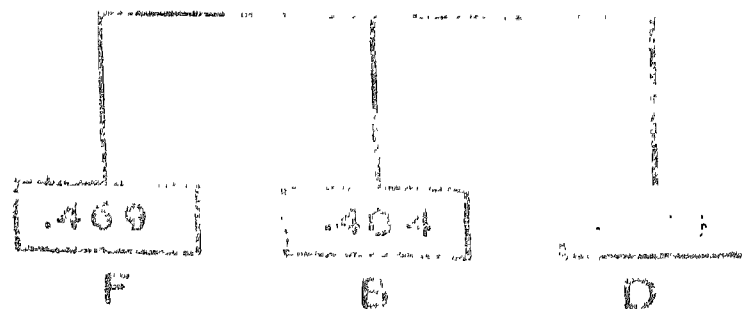




FIG. 13



VARIMAX FACTOR V  
SIGNIFICANT LOADINGS





In the case of Varimax Rotated Factor IV, there is a change of only one variable, i.e., instead of measure D, the measure C has significant loading on this factor, other variables remaining the same as in the case of Original Factor. However, the sizes of loadings as well as the order of variables with respect to the size of factor loadings get changed. The new order is  $-I_4(.462)$ , J(.473), O (.621) and L(.625). This factor accounts for 9.0 % of common factor variance and 4.4 % of total variance (vide Table 23). Keeping in view the comprehensive nature of the traits of personality having significant factor loadings, i.e.,  $O_4$  (relaxed-tense), J(softful-circumspect), O (secure-insecure) and L(obedient-assertive), this factor can be named as Behavioural Factor.

#### Factor V

Original Factor V shows bi-polar characteristics as the factor loading of the personality trait D(phlegmatic-excitabile) is negative while the factor loadings of the variables : O (secure-insecure), ADJ (adjustment) and L(obedient-assertive) are all positive as given in Fig. 13. The highest loading has been shared by D(-.466). This factor accounts for 7.0% of common factor variance and 3.4 % of total variance (vide Table 27).

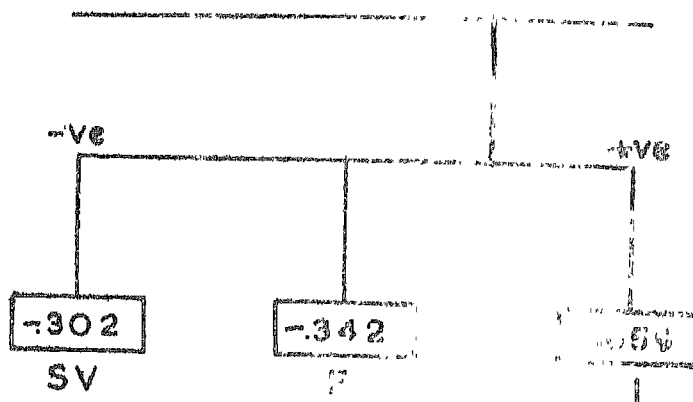
The personality traits, F,B and D are having significant positive factor loadings in the case of Varimax Rotated Factor V. The sequence of personality variables with respect to the size of factor loadings is F(.469), B(.434) and D(.623). This factor accounts for 7.5% of common factor variance and 3.7 % of total





FIG.- 14

ORIGINAL FACTOR VI  
SIGNIFICANT LOADINGS



VARIMAX FACTOR VI  
SIGNIFICANT LOADINGS

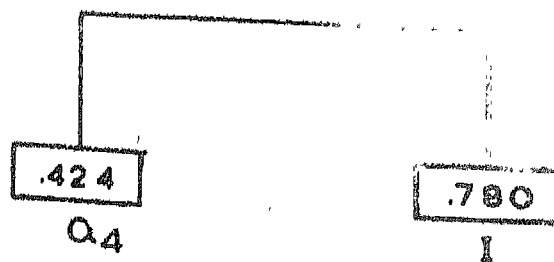
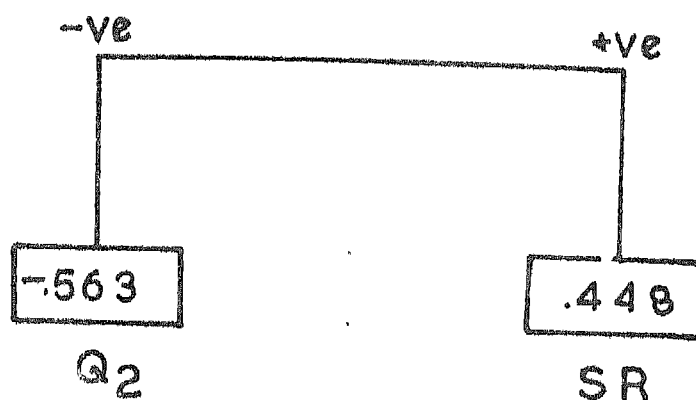


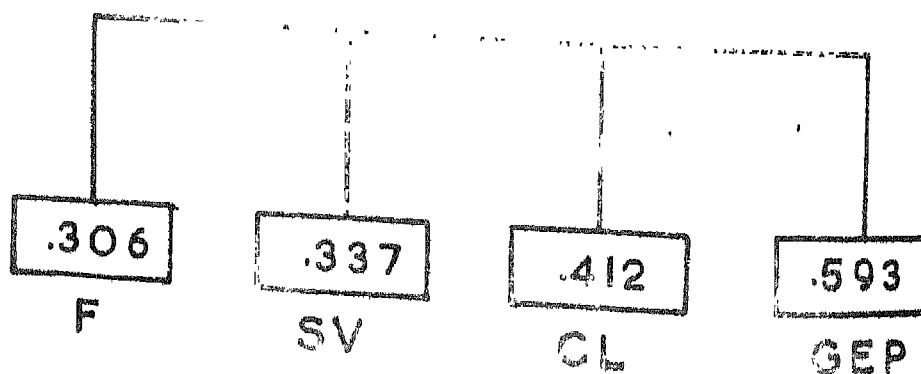


FIG. 15.

ORIGINAL FACTOR VII  
SIGNIFICANT LOADINGS



VARIMAX FACTOR VII  
SIGNIFICANT LOADINGS



variance (vide Table 23). In view of the characteristics of the personality traits -F(sober-headless), B(concrete-abstract thinking) and C(phlegmatic-excitabile) - having significant factor loadings, this factor may be named as Emotional Factor.

#### Factor VI

The results presented in Fig. 14 show that Original Factor VI is bi-polar in nature as the factor loadings of the variables S/(-.302) and P(-.342) are negative while that of the measure of I(.659) is positive. The highest loading is shared by I(toughminded-tenderminded). This factor accounts for 6.7 % of common factor variance and 3.3 % of total variance (vide Table 27).

In the case of Varimax Rotated Factor VI only two variables  $Q_4$ (.424) and I(.780) are having significant factor loadings. It accounts for 7.0 % of common factor variance and 3.4 % of total variance (vide Table 23). On the basis of the adjectives used to describe the two traits of personality, i.e.  $Q_4$ (relaxed-tense) and I(toughminded-tenderminded) having significant factor loadings on Varimax Rotated Factor VI, it can be named as Temperamental Factor.

#### Factor VII

Original Factor VII also shows bi-polarity as out of the two variables having significant factor loadings on this factor, one ( $Q_2$ ) has negative (-.563) loading while the other (CR) has positive (.498) factor loading (Fig. 15). It accounts for 6.4% of common factor variance and 3.1 % of total variance (vide Table 27).







FIG. 16

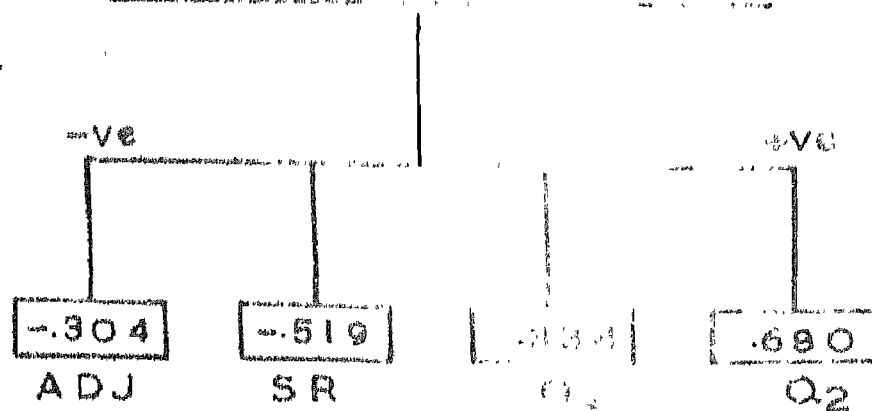
# ORIGINAL FACTOR VII

## SIGNIFICANT LOADINGS



# VARIMAX FACTOR VIII

## SIGNIFICANT LOADINGS



Varimax Rotated Factor VII has the significant loadings of the variables  $F(.306)$ ,  $IV(.337)$ ,  $CI(.412)$  and  $AI(.593)$ . It accounts for 7.8% of common factor variance and 3.8% of total variance (vide Table 23). Three out of the four variables having significant loadings on this factor are the measures of the dimensions of adolescent thought. Hence, on the basis of the nature of the variables having high factor loadings, this factor may be named as Group Factor of Adolescent Thought.

#### Factor VIII

The results presented in Fig. 16 show that Original Factor VIII is bi-polar in nature. The variables  $F(-.341)$  and  $AI(-.393)$  have negative factor loadings while the measure of  $S(.467)$  has positive factor loading. This factor accounts for 6.0% of common factor variance and 3.0 % of total variance (vide Table 27).

Varimax Rotated Factor VIII also shows bi-polarity. The factor loadings of the measures  $AI(-.304)$  and  $FI(-.319)$  are negative and those of  $Q_3(.334)$  and  $Q_2(.680)$  are positive. It accounts for 7.0 % of total variance (vide Table 28). It is a group factor of a complex nature but on the basis of the nature of the variables having highest positive loadings, i.e.,  $Q_2$  (group dependent-self sufficient) and  $Q_3$  (uncontrolled-self-controlled), it can be named as Social Factor.

The review of the descriptions of eight factors both original and varimax, clearly demonstrates that in the light of these results the ninth hypothesis of the study (the measures of intelligence, academic achievement, reasoning ability, space



relations, adjustment and personality cluster in specific constellations with the measures of the dimensions of adolescent thought explaining thereby the common factor variance) stands verified and approved.

### The Current Picture of the Structure of Adolescent Thought

The factorial structure identified through this study consists of eight orthogonal factors extracted by Principal Axes Method. The factors are : General Intellectual Factor of Adolescent Thought, Academic Achievement Factor, Adjustment Factor, Behavioural Factor, Emotional Factor, Temperamental Factor, Group Factor of Adolescent Thought and Social Factor. The distinguishing characteristic of the structure of adolescent thought identified in the present study is that it consists of, in addition to intellectual and academic factors, a good number of personality factors. None of these factors could be identified in the earlier studies as they had not taken into consideration this hot cognition while studying the formal thought. Secondly, Piaget Type Tasks included in this study were administered as paper-pencil tests and thus, the attempt may be characterized as psychometric rather than clinical. Some other research workers like Longoot (1955), Raven (1973), Thayer (1979), Staver and Gabel (1979) and Tisher (1971) have also attempted to develop paper-pencil tests for investigating the adolescent thought and have extracted factors using different tasks or tests, populations and techniques of analysis. The



results of these studies indicate that the formal thought which appears during adolescence is being scratched factorially as majority of the studies are handicapped both in terms of adequate samples as well as of the dimensions of the adolescent thought investigated. Most of the studies are contented with one or two factors only as none of them has gone further than three factors except Bandhu, Vaidya and Vaidya & Misra.

It is not possible and logical even to compare the findings of the various studies which have attempted to analyse the formal thought mathematically. The reason being that the findings come from different samples using various tests and techniques. Even then for the sake of clarity, structurally speaking, if the different results are put side by side the picture that emerges is as follows:

Sr. No.	Factor	Psychological Interpretations	Authors
1	2	3	4
i.	First Factor	i. General Intellectual Factor	Jatav (1964), Beard (1957), De Lencos (1969), Mac Arthur (1962), Peel (1955), Bandhu (1980), Stever and Gabel (1979), Tuddenham (1970).
		ii. Schematic Learning General	Bart (1971), Lawson (1975), Vaidya (1975)
		iii. General Adjustment	Vaidya and Misra (1974)
		iv. Formal Operational Thought	Abramowitz (1978), Shayer (1979)
		v. Attainment Factor	Vaidya (1964)
		vi. Algebraic Aptitude	Joshi (1970)





1	2	3	4
2. Second Factor	i. Piagetian Cognitive Development.	Staver and Gabel (1973)	
	ii. Seeing the Problem as a whole.	Vaidya and Misra (1974)	
	iii. Academic Achievement Factor.	Sandhu (1980)	
	iv. Adjustment	Vaidya (1975)	
	v. Practical Factor	Vaidya (1964)	
	vi. Symbolic Substitution	Joshi (1970)	
3. Third Factor	i. Piagetian Logical Operations Test.	Staver and Gabel (1973)	
	ii. Formulating Hypotheses	Vaidya and Misra (1974)	
	iii. Adjustment Factor	Sandhu (1980)	
	iv. Problem Orientation	Vaidya (1975)	
	v. Interest Factor	Vaidya (1964)	
4. Fourth Factor	i. Interest in Generating Difficult Problems	Vaidya and Misra (1974)	
	ii. Behavioural Factor	Sandhu (1980)	
	iii. Sensing Problems	Vaidya (1975)	
	iv. Adjustment Factor	Vaidya (1964)	
5. Fifth Factor	i. Newness of the Problem	Vaidya & Misra (1974)	
	ii. Emotional Factor	Sandhu (1980)	
	iii. Symbolisation	Vaidya (1975)	



6. Sixth Factor	i. Temperamental	Gandhu (1980)
	ii. Testing Hypotheses	Vaidya (1975)
7. Seventh Factor	i. Group Factor of Adolescent Thought	Gandhu (1980)
	ii. Being Constant Difference	Vaidya (1975)
8. Eighth Factor	i. Social Factor	Gandhu (1980)
	ii. Aspect Character	Vaidya (1975)
9. Ninth Factor	Seeing the Problem as a whole	Vaidya (1975)
10. Tenth Factor	Intelligence	Vaidya (1975)

---

### Concluding Statement

In this frame of reference, it should not be forgotten that factor analysis is a highly mathematical technique as well as an advanced educational technology. The various factors failing to appear in a definite way should be further subjected to empirical testing by carrying out highly imaginative studies using factorially known tests as reference points. The various tests used should cover as many diverse populations meeting fairly well the intended objective criteria of reliability and validity. Similarly, the sizes of the samples should not invariably be less than four times the number of tests used. After having done this, the growth of factors should be clinically explored and the same be checked



empirically to test whether the findings come from different chips of different blocks or the different chips of the same block. Whatever be the nature of these findings, they are bound to alter the already proposed structures of intellect, a periodic table of intelligence like the one in chemistry, if it exists, may become available for the benefit of learning psychologists. Until then, as it is apparent, the studies undertaken simply reflect the possible structure of adolescent thought as imaginatively proposed by the Geneva School, using symbolic logic.









## CHAPTER VII

## Hump Effect encountered : An Observation of Second Interest

Jean Piaget, while working with Theophile Simon in Paris in 1930 to standardise a test, found that children of a particular age commit almost similar type of errors. Later on, keeping in view the similarities in the thinking processes at different age levels, he propounded the concept of the 'Stages of Development'. It is a fine coincidence that Vaidya (1975) too encountered 'hump' in the number of errors while investigating the errors committed by the students in solving some problems. He noticed a sudden increase in the errors with the increase in age during the formal-operational stage contrary to the expectations that the errors should go on diminishing with age. The number of errors, however, declined at subsequent age levels gradually to a minimum. He raised some pertinent issues about this phenomenon, i.e., Is it the case of an adolescent playing with figures thoughtlessly in the hope of being favoured with good luck? Is it a case of lack of seriousness on his part? Is it the case of being caught between the horns of a dilemma and getting mired? Is it the case of hot chase trying hard to choose in haphazard directions as if in the manner of closing in on the problem? Does it illustrate that mastery of a thought process is through a path uphill, thorny and often erratic? Does the adolescent regress as if on an adventurous Piagetian journey during which he is trying hard to educate



himself, thinking that the right path to concept development lies in flourishing on experimental failures or a problem solving situation in which either understanding suffers a dip or errors a hump? Is it a fact of rubbing his schemes of thought wrongly, especially when he has personal reservations about his self acquired knowledge in contrast to school learning which does not set right his firmly held self centred thoughts? These queries definitely needed further clarifications. The matter was referred to Prof. J.L. Bruner for comments and guidance about this elusive phenomenon. Bruner (1976) described that "The type of error that you refer to, which we speak of as growth error, is one in which a growing child tries out a new strategy although it is not well developed and uses it in place of an older one which has been working well. It is errors of this sort which suggest to me the venturesomeness of learning during this early period, the human beings are willing to shift to a less certain and more powerful strategy, before they have it under control, in preference to one which is safe, sound and dull." Later on, the phenomenon of 'hump effect' was also studied from the developmental aspect of thinking processes by Vaidya & Sandhu (1978)<sup>2</sup>, where it has been found that 'hump effect' (dip in the real sense) appears when a thought process moves from a lower stage to a higher stage, particularly, during the transitional period, i.e., the period between any pair of the two succeeding stages. The data given in The Essential Piaget show that Piaget & Inhelder (1977), Lovell & Ogilvie

---

<sup>2</sup>See appendix (v).



(1977) and Alkind (1977) did encounter this phenomenon but missed referring to it in their studies.

In the present study also the 'hump effect' has been noticed on three dimensions of adolescent thought, i.e., ratio and proportion (RP), grasping the essence of the problem (LP) and space visualization (V). The data regarding the mean scores and standard deviations of the different age groups with respect to the three dimensions of adolescent thought are presented in Table 30.

TABLE 30

MEAN SCORES AND STANDARD DEVIATIONS ON THE  
DIMENSIONS OF RATIO AND PROPORTION, GRASPING THE  
ESSENCE OF THE PROBLEM AND SPACE VISUALIZATION  
AT DIFFERENT AGE LEVELS

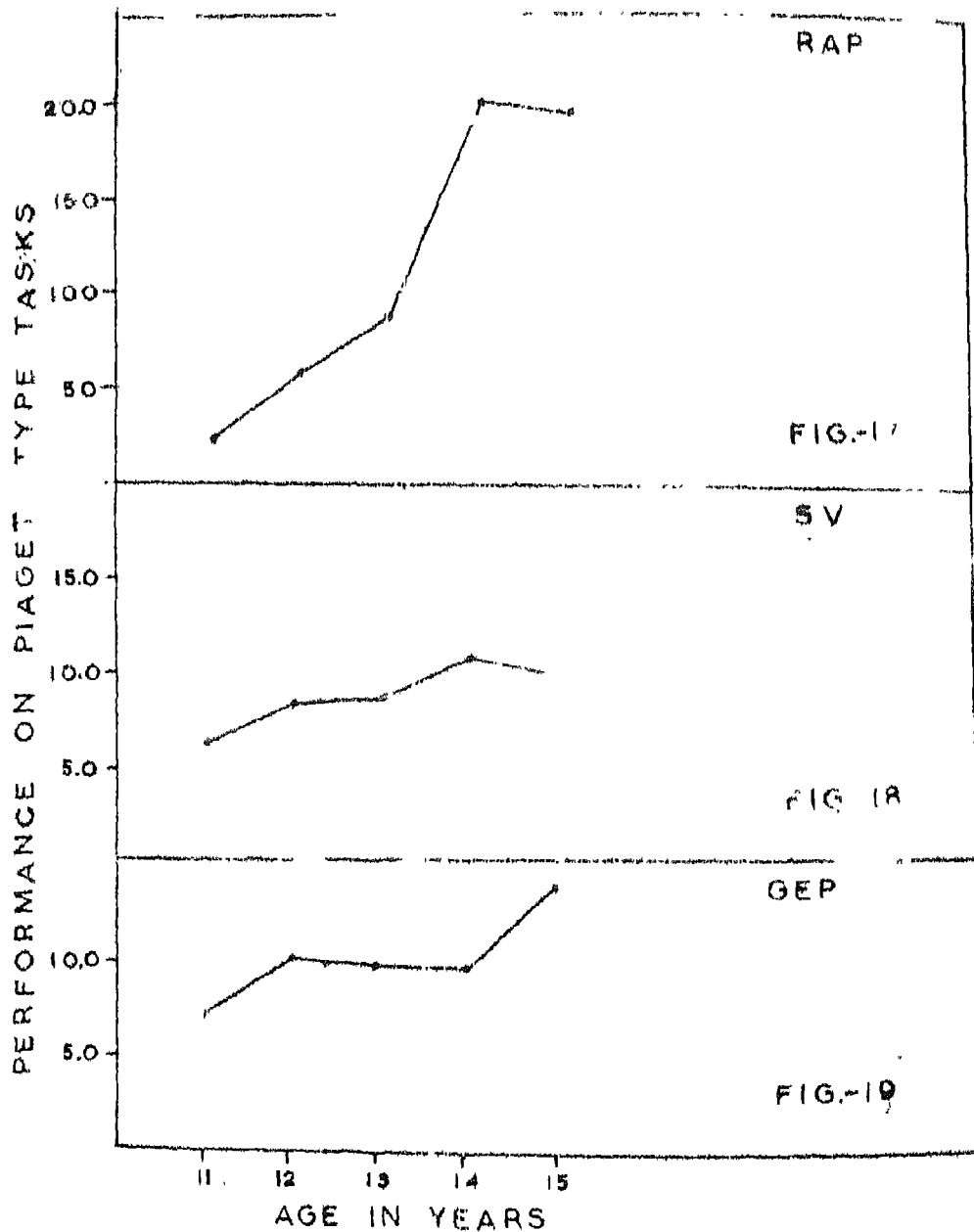
Sr. No.	Dimensions of Adoles- cent thought	Mean Scores and Standard Deviations at Different Age Levels				
		11 <sup>+</sup>	12 <sup>+</sup>	13 <sup>+</sup>	14 <sup>+</sup>	15 <sup>+</sup>
1.	RP	.832 (.558)	.898 (1.720)	.898 (1.832)	2.094 (2.614)	1.977 (2.560)
2.	LP	5.691 (3.868)	7.971 (4.734)	8.257 (4.692)	10.458 (4.548)	9.874 (4.709)
3.	V	.679 (.968)	1.005 (1.050)	.960 (1.144)	.963 (.997)	1.394 (1.236)

Standard Deviations are given in brackets.





HUMP EFFECT AS OBSERVED REGARDING  
THE PERFORMANCE ON DIFFERENT  
PIAGET TYPE TASKS.





The phenomenon has been illustrated more clearly through the graphical presentation of the results given in Table 20. The figures 17, 18 and 19 demonstrate the 'hump effect' with respect to the dimensions of adolescent thought RA, SV and GEP respectively.

It is important to note here that the occurrence of hump, or dip is not bound up with any particular age level in the case of the dimensions of adolescent thought described above, rather it occurs at different age levels depending upon the thought process under study. A similar trend has been noticed in the case of the children of lower age levels with respect to the concepts of concrete-operational stage in the studies of Piaget & Inhelder (1977), Lovell & Ogilvie (1977) and Alkind (1977). Thus, it can be said that 'hump effect' appears at all ages, the thought process being the determining factor, among pupils belonging to different intellectual levels when new schemes of thought are under development.

Though this phenomenon has been viewed quite comprehensively still there is a chance that sampling fluctuations might influence the number of errors as well as the performance on dimensions of adolescent thought at different age levels, since all the studies mentioned in this context are cross-sectional in nature. Hence, the phenomenon of 'hump effect' needs further verification through the longitudinal studies on the various aspects of the thought processes associated with the different age levels.



## CHAPTER VIII

### Summary and Conclusions



## CHAPTER VIII

## Summary and Conclusions

## Introduction

Now-a-days the major interest of the psychologists and educationists is not only in understanding the individuals but in studying the general trend of the development and structure of the human mind. The scientific investigation of thinking processes and structure of human mind is gaining importance as the growth of highly logical mind has become one of the most important goals of the educational instruction in the modern society. Jean Piaget has contributed immensely to the whole field of psychology in general and to the modes of human thinking particularly. He speaks of qualitative changes in the underlying processes of thinking leading to the mental growth. He groups these qualitative changes into a succession of four global stages of development : the sensory-motor stage (birth to 2 years), the pre-operational stage (2 to 7 years), the concrete-operational stage (7 to 11 years) and the formal-operational stage (11 to 15 years). The important feature of Piaget's theory is that he is more interested in studying the cognitive structure of developing human mind than its function and content. Cognitive structure refers to the form or shape or pattern that cognition takes during each of Piaget's stages of mental development. The present study was undertaken with a view to investigate the structure of thought at formal-operational stage. At this stage, the refinements of adult



thought are acquired. The thinking processes become abstract and they no longer depend on the observed data. They can be carried out on hypothetical information. Thus, the formal thought is a generalised orientation, sometimes explicit and sometimes implicit, towards problem solving : an orientation towards organising data (combinatorial analysis), isolation and control of variables, the hypothetical and logical justification and proof. Piaget believes that intelligence reaches ultimate equilibrium at the formal-operational stage.

There is a sufficient research evidence that in many cases the subjects of the age group 11 to 15 years which we may call adolescents were found not developed to the formal-operational level. Since primitive structures form the basis of the more advanced-level structures, an inter-related criteria of covering the various dimensions of formal-operational thought alongwith a few dimensions of concrete-operational thought, were worked out and named as adolescent thought. Thus, adolescent thought shows a form of grouping : concrete operational and coordinating concrete-logical as described by Gurin (1975) also.

It is true to say that in spite of large number of excellent works published on the affective, social and emotional domain of adolescents, little work has appeared in the psychological literature on the adolescent's thinking processes. However, thinking in general has been the subject of study from various standpoints by many philosophers and psychologists. There seems to be a scarcity of literature to which reference could be made regarding the mathematical analysis of the adolescent thought.





The effort has been made by this study to analyse the adolescent thought mathematically through factor analysis to identify its underlying structure, and to explore the relationship of the development of adolescent thought with the variables of age, sex, intelligence, academic achievement, reasoning ability, space relations, adjustment and other personality traits. The ten dimensions of adolescent thought investigated through the present study consisted of the measures of classification, grouping of thought, generalization to arithmetical and algebraic symbols, permutations and combinations, ratio and proportion, formulation of probing questions, interpretation and coordination of information, stating and testing hypotheses, space visualization and grasping the essence of the problem. A paper-pencil test of Piaget Type Tasks based on the above dimensions of adolescent thought was developed by the investigator for group administration.

### Hypotheses

The study was undertaken to test the following hypotheses:

1. Does the performance on Piaget Type tasks increase with age during the formal-operational period?
2. Whether boys and girls perform equally well on Piaget Type Tasks?
3. The measures of intelligence, both verbal and non-verbal, correlate significantly with the measures of the dimensions of adolescent thought.



4. There exists a significant relationship between the measures of academic achievement and the variables of the dimensions of adolescent thought.
5. The measures of reasoning ability and space relations yield a significant correlation with the various measures of adolescent thought.
6. The measure of adjustment is significantly related to the performance on Piaget Type Tasks.
7. The measures of personality exhibit significant relationship with the measures of the dimensions of adolescent thought.
8. The performances on Piaget Type Tasks form an interrelated measure, of the adolescent thought and exhibit a unifactor structure.
9. The measures of intelligence, academic achievement, reasoning ability, space relations, adjustment and other personality traits cluster in specific constellations with the measures of the dimensions of adolescent thought explaining thereby the common factor variance.

#### Sample

A sample of 986 students (505 boys and 481 girls) was drawn randomly among the students of twelve high schools of the rural areas in Punjab taking almost equal number of boys and girls of the age groups of 11<sup>+</sup>, 12<sup>+</sup>, 13<sup>+</sup>, 14<sup>+</sup> and 15<sup>+</sup> and studying in grades VI, VII, VIII, IX and X respectively.

#### Tools

The data were collected using the following tools:

1. Test of Piaget Type Tasks (investigator).



2. Culture Fair Intelligence Test-Scale 9 (Cattell).
3. General Mental Ability Test (Jalota).
4. Reasoning Ability Test (Dubey).
5. Space Relations (SAT) (Bennett, et al).
6. Adjustment Inventory (Asthana).
7. High School Personality Questionnaire - HSPQ (Cattell).
8. Academic Achievement in Five School Subjects (From School Records).

#### Statistical Treatment of Data

The descriptive statistics such as mean, median, mode, standard error, standard deviation, skewness, kurtosis were computed through computer for each variable included in the study which showed that the measures of the variables were normally distributed with minor variations. The relationships between the measures of the dimensions of adolescent thought and the measures of the independent variables, namely intelligence, reasoning ability, space relations, academic achievement, adjustment and personality traits were worked out by computing product moment correlations. One-way analysis of variance technique was used to determine the age and sex differences regarding the performance on Piaget Type Tasks during the formal-operational period at different age levels.

To identify the factorial structure of adolescent thought, the data on the 34 measures were put into 34 x 34 correlation matrix and subjected to factor analysis by Principal Axes Method. The computations were carried out through "MAYAD-1022 Computer"



at Computronics India, New Delhi, using P.A.-1 factor analysis programme from the "Statistical Package for the Social Sciences (SPSS)" by Nie, et al (1970).

### Findings and Conclusions

Findings of the study and the conclusions drawn are presented here briefly:

- i) The values of F-ratios computed between the five age groups with respect to their performance on ten Piaget Type Tasks were all found to be significant at .01 level (vide Table 10) and a gradual increase in mean performance at successive age levels was noticed (Table 11). Hence, it has been concluded that performance on Piaget Type Tasks increases with age during the formal-operational period.
- ii) The values of thirtyone t-ratios, out of the sixty t-ratios computed between the performances of boys and girls on ten Piaget Type Tasks at each of the five age levels as well as for the combined groups, were found to be significant. The boys showed superiority in all the cases of significant t-ratios (vide Tables 12 to 21) which led to the conclusion that boys perform either equal to or better than girls on Piaget Type Tasks at respective age levels.
- iii) The coefficients of correlation between the measures of intelligence both verbal and non-verbal and the variables of the





dimensions of adolescent thought were all found to be significant at .01 level (vide Table 23). It has been concluded, therefore, that measures of intelligence correlate significantly with the measures of the dimensions of adolescent thought.

iv) Looking through the analytical picture of the coefficients of correlations, it has been found that all the five measures of academic achievement were significantly correlated with the variables of the dimensions of adolescent thought except the dimensions of ratio and proportion and space visualization (vide Table 23). A conclusion has been arrived at that academic achievement has a significant bearing on the development of adolescent thought.

v) The coefficients of correlation between the measures of reasoning ability and space relations on one hand and the measures of the dimensions of adolescent thought on the other hand were all found to be significant at .01 level (vide Table 23). Thus, the measures of reasoning ability and space relations (measures of abstract thinking) prove to be the determinants of the development of adolescent thought.

vi) The values of all the coefficients of correlation between the measure of adjustment and the variables of the ten dimensions of adolescent thought were significant at .01 level (vide Table 23). It has been confirmed, therefore, that the development of formal thinking leads to better adjustment of the individual and vice versa.



Factor, Group Factor of Adolescent Thought and Social Factor. Keeping in view the significant factor loadings of the different factors, it has been concluded that the measures of intelligence, academic achievement, reasoning ability, space relations, adjustment and other personality traits cluster in specific constellations with the measures of the dimensions of adolescent thought explaining thereby the common variance operating among them.

### Educational Implications

All over the world, education system is under fire from all sections of the society mainly because it is not delivering the goods properly, the emphasis has always remained on memorization. Thus, the qualitative development of the pupils remain hampered even upto adulthood. That is why, as discussed in Chapter III, majority of the students are found operating at concrete-operational level even at college stage. Since, it is very essential to develop a curriculum and teaching methods at school level keeping in view, psychologically speaking, the structure of the adolescent thought determined empirically as in the case of the present study. The other implications of the findings of the study may be described as follows:

- 1) The development of the various traits of personality, such as obedience, feeling of security, emotional stability, self-discipline, relaxation, phlegm, abstract thinking, conscientiousness, outgoing-tendencies and adventurism



should be given more emphasis as they help in the development of adolescent thought as found in this study.

iii) More attention should be paid towards the adjustment of the students at school level as it has been found to be, invariably, a correlate of the different dimensions of adolescent thought.

iii) Boys and girls should not be segregated in the classroom on the basis of sex as there does not exist a definite evidence regarding the superiority of the boys over the girls. Moreover, girls should be given more freedom and recognition, so that they avail equal opportunities required for the development of adolescent thought.

iv) The age-related development of adolescent thought during adolescence does suggest that there should not be a large variation in age of the students studying in a particular class, otherwise, the classroom instruction can not be turned to a uniform frequency.

v) Since the measures of abstract thinking such as reasoning ability and space relations are found to be significantly related with the development of adolescent thought, exercises of abstract thinking should be included in day to day teaching which will promote the development of formal thought and consequently the cognitive functioning as a whole.



- vi) The results of factor analysis show the existence of a general intellectual factor of adolescent thought. The emphasis should, therefore, be given on the development of the overall abilities of the students, rather than on a special type of orientation only.
- vii) Lastly, an intellectual atmosphere should be created in the class rooms. It may also help in the development of the adolescent thought as the measures of intelligence, both verbal and non-verbal, are found to be significantly correlated with all the dimensions of adolescent thought irrespective of their form and content.

#### Problems for Further Research

The research on thinking processes and consequently on its structure is a very complex and imaginative phenomenon as the processes involved in thinking and the factors identified in the case of structure are not directly observable entities. Thus, the conclusions drawn remain purely hypothetical. Even then, they give way to an understanding of the functioning and of the vectors of mind with regard to thinking and structure of thought respectively. No study is complete in itself. It raises further queries regarding the issues involved in its investigation. The present study also raises some issues which are proposed to be undertaken in the near future.

- 1) The results of this study could not confirm the effect of sex on the development of adolescent thought, therefore, it





should be verified whether the structure of thought remains the same both in the case of boys and girls taken separately during adolescence.

- ii) The dimensions of adolescent thought are not found uniformly related with the various personality factors. Hence, the relationship between the personality factors and the dimensions of adolescent thought should be investigated more comprehensively controlling the other variables.
- iii) The development of adolescent thought has been found closely related with the increase in age levels. Thus, it has become a matter of deep concern to verify the invariance of the structure at different age levels, i.e., 11<sup>+</sup>, 13<sup>+</sup>, 15<sup>+</sup>, 14<sup>+</sup> and 15<sup>+</sup> years with the development of adolescent thought. It will also clarify whether the different abilities integrate or differentiate or develop independently with the increase in age.
- iv) The hump effect, witnessed on only few dimensions, should be further explored taking into account more tests related with the dimensions of adolescent thought for either accepting or rejecting the phenomenon.
- v) The possibility of the existence of the dimensions of adolescent thought other than those investigated in this study should be explored and their relationship with the dimensions already investigated should be studied.
- vi) The mathematical structure of the different school subjects should also be determined so that it could be matched with the cognitive structure of the pupils while framing the school curriculum.



136107070



## Bibliography

- Abramowitz, G. (1975). Adolescent understanding of Proportionality. Ph.D. Thesis, Stanford University.
- Alexander, H.P. (1938). Intelligence, Concrete and Abstract. *British Journal of Psychological Monographs Supplements*, 19, 177.
- Asthana, I.T. (1968). *Manual of Direction & Norms for Adjustment Inventory*. Rupa Psychological Centre, Varanasi.
- Asthana, I.T. (1976). *Adjustment Inventory*. Rupa Psychological Centre, Varanasi.
- Aune, B. (1967). Thinking. In Paul Edwards (Ed.). The Encyclopedia of Philosophy. The Macmillan Company and the Free Press, New York. 8, 100.
- Bart, J.M. (1971). The Factor Structure of Formal Operations. *British Journal of Educational Psychology*, 41, 70-77.
- Bartlett, P.C. (1958). Thinking : An Experimental Study. George Allen and Unwin Ltd., London.
- Beard, R.M. (1957). An Investigation of Concept Formation Among Infant School Children. Ph.D. Thesis, Institute of Education, London.
- Beard, R.M. (1969). An Outline of Piaget's Developmental Psychology. Routledge and Kegan Paul Ltd., London.
- Bennett, et al. (1959). Space Relations Test (SAT). Manassayan, New Delhi.



- Bennett, et al. (1950). Manual for the Differential Aptitude Tests (DAT). The Psychological Corporation, New York.
- Blast, A. & Beffel, J.C. (1974). Adolescence and Formal Operations. Human Development, 17, 344-363.
- Bolton, E. (1972). The Psychology of Thinking. Methuen and Co. Ltd., London.
- Brainerd, L.L. (1973). Piaget's Theory of Intelligence. Prentice-Hall Inc. Englewood Cliffs, New Jersey.
- Brown, J. & Stephenson, L. (1933). A Test of the Theory of Two Factors. British Journal of Psychology, 23, 352-370.
- Brown, J. & Thomson, G.L. (1941). The Essentials of Mental Measurement. Harvard University Press, Cambridge.
- Bruner, J.W. et al. (1956). A Study of Thinking. John Wiley, New York.
- Burt, C. (1941). The Factors of the Mind: an Introduction to Factor Analysis in Psychology. Mac Millan, New York.
- Burt, C. (1944). The Structure of the Mind: A Review of the Results of Factor Analysis. British Journal of Educational Psychology, 19, 176-199.
- Cuswell, G.F. (1936). Elements of Thinking in Solving Problems. University of Chicago Press, Chicago.
- Case, R.B. & Collinson, J.M. (1963). The Development of Formal Thinking in Verbal Comprehension. British Journal of Psychology, 52, 103-111.





- Cattell, R.M. (1953). Factor analysis. Harper & Bros., New York.
- Cattell, R.M. & Deloff, L. (1967). High School Personality Questionnaire HPQ. (Hindi Version by S.P. Kapoor & K.T. Mehrotra). The Psycho-Centre, New Delhi.
- Cattell, R.M. & Cattell, D.L. (1976). Handbook for the Jr. - High School Personality Questionnaire. (1976). The Psycho-Centre, New Delhi.
- Cattell, R.M. & Cattell, A.K. (1960). Handbook for the Junior High School Intelligence Test-Scale 2. The Psycho-Centre, New Delhi.
- Cattell, R.M. & Cattell, A.K. (1964). Junior High Intelligence Test-Scale 2. The Psycho-Centre, New Delhi.
- Chiappetta, M.L. & Alfred, T.C. (1975). The Effectiveness of Verbal Label Training in Aiding Second Grade Pupils to Transfer their Classificatory Skill. Journal of Research in Science Teaching, 12, 2, 183-191.
- Clayton, V. & Overton, J.W. (1976). Concrete and Formal Thought Processes in Young Adulthood and Old Age. International Journal of Aging and Human Development, 7, 3, 237-245.
- Cloutier, R. & Goldschmid, M.L. (1976). Individual Differences in the Development of Formal Reasoning. Child Development, 47, 1097-1102.
- Cohen, J., Ed. (1964). Handbook in Psychology. George Allen and Unwin Ltd., London.
- Dale, L.G. (1970). The Growth of Systematic Thinking: A Replication and Analysis of Piaget's First Chemical Experiment. Australian Journal of Psychology, 22, 277-286.



- Delencos, H.H. (1969). The Development of Conservation in Aboriginal Children. *International Journal of Psychology*, 4, 355-369.
- Dewey, J. (1910). How We Think. D.C. Heath & Co., London.
- Dhaliwal, A.C. (1977). Personality Correlates of Academic Over-Under Achievement. Guru Nanak Dev University, Amritsar, Punjab.
- Dubey, L.N. (1974). Manual of Reasoning Ability Test. National Psychological Corporation, Agra.
- Dubey, L.N. (1978). Reasoning Ability Test. National Psychological Corporation, Agra.
- Dudek, T.T. et al. (1969). Relationship of Piaget Measures to Standard Intelligence and Motor Scales. *Perception and Motor Skills*, 29, 351-362.
- Dulit, G. (1973). Adolescent Thinking a' la Piaget : The Formal Stage. *Journal of Youth and Adolescence*, 7, 281-301.
- Dunlop, D.L. & Fazio, P. (1975). A study of Abstract Preferences in Problem Solving Tasks and Their Relationship to Abstract Ability and Formal Thought. Paper Presented at the Annual Meeting of the National Association for Research in Science Teaching, Los Angeles, California.
- Elkind, D. (1962). Quantity Conceptions in College Students. *Journal of Social Psychology*, 57, 439-453.
- Elkind, D. (1977). Children's Discovery of Conservation. In Gruber & Vonèche (Eds.), *The Development of Conservation*. Routledge Kegan Paul Ltd. London.



- Alkousay, A. A. (1935). The Visual Perception of Space.  
British Journal of Psychological Monographs  
Supplements, 20, 89.
- Encyclopaedia Britannica. (1966). Encyclopaedia Britannica,  
Inc. Chicago. 22, 133.
- Erikson, E. L. (1968). Identity : Youth and Crisis.  
Faber & Faber, 3 Queen Square, London.
- Eysenck, H. J. (1939). Critical Notice of 'Primary Mental  
abilities' by L. L. Thurstone. British Journal  
of Educational Psychology, 9, 270-278.
- Eysenck, H. J. (1967). Intelligence Assessment : A Theoretical  
and Experimental approach. British Journal of  
Educational Psychology, 37, 81-98.
- Eysenck, H. J. (1979). The Structure and Measurement of  
Intelligence. Springer-Verlag, Berlin  
Heidelberg, New York.
- Flavell, J. H. (1963). The Developmental Psychology of Piaget.  
Pinguet, D. Van Nostrand Company Inc., Toronto,  
Canada.
- Freud, S. (1933). Psychoanalysis for Teachers and Parents.  
Amerson, New York.
- Freud, S. (1949). An Outline of Psychoanalysis, Norton, New York.
- Fruchter, B. (1967). Introduction to Factor Analysis.  
Affiliated East - West Press Pvt. Ltd., New Delhi.
- Garrett, L. B. (1971). Statistics in Psychology and Education.  
Vohla, 122 Gur and Khana Pvt. Ltd., Bombay,  
212-246.



- Germain, J.C. et al. (1976). The Personality of the Child and the Utilization of Operative Thought. *Infance*, 4-5, 399-405.
- Graybill, L.L. (1974). A Study of Sex Differences in the Transition from Concrete to Formal Thinking Patterns. *Dissertation Abstract International*, 34, 7, 3905 A.
- Graybill, L.L. (1975). Sex Differences in Problem-Solving Ability. *Journal of Research in Science Teaching*, 12, 4, 341-346.
- Green, D.L., Ed. (1971). Measurement and Piaget. McGraw-Hill Book Co., New York.
- Gruber, M. & Vonèche, J.F. Ed. (1977). The Essential Piaget. Routledge & Kegan Paul Ltd., London.
- Guerin, H.O. (1973). A Quasi - Simplex and Alpha Factor Analysis of Piaget Based Logical Operations. *Dissertation Abstract International*, 33, 10, 6512.
- Guilford, J.P. (1936). Psychometric Methods. McGraw-Hill Book Co., New York.
- Guilford, J.P. (1940). Human Abilities. *Psychological Review*, 47, 367-399.
- Guilford, J.P. (1956). The Structure of Intellect. *Psychological Bulletin*, 53, 267-293.
- Gunnels, F. (1967). A Study of the Development in Logical Judgements in Science of Successful and Unsuccessful Problem Solvers in Grades Four Through Nine.
- Harman, L.H. (1960). Modern Factor Analysis. The University of Chicago Press, Chicago.





- Katab, A. (1964). The Definition and Measurement by Verbal Methods of the Ability to Think Critically. M.A. Thesis, Institute of Education, London.
- Kathway, J.S. (1975). The Unique Contribution of Piagetian Measurement to Diagnosis, Prognosis and Research of Children's Mental Development. In Cohen and Golia Hodgill (Eds.), Piagetian Research: Compilation and Commentary. NER Publishing Company, London, 1976. 3, 174.
- Haggings, C.A. & Gaito, A.J. (1971). Maturity of Formal Operational Thought in Adolescents. Proceedings of 79th Annual Convention of the American Psychological Association, Washington, D.C.
- Kolczinger, K.J. (1933). Statistical Methods for Students in Education. Ginn & Co., Boston.
- Kolczinger, K.J. & Terman, L.L. (1933). Comparison of Two Factorial Analyses. *Psychometrika*, 3, 45-60.
- Koss, A. (1974). Formal Operational Thought and the High School Science Curriculum. Paper Presented at the National Association for Research in Science Teaching, Annual Meeting, Chicago.
- Humphrey, G. (1951). Thinking. Methuen & Co., Ltd. London.
- Inhelder, B. & Piaget, J. (1958). The Growth of Logical Thinking from Childhood to Adolescence. Routledge & Kegan Paul Ltd., London.
- Jackson, S. (1968). The Growth of Logical Thinking in Normal and Sub-Normal Children. *British Journal of Educational Psychology*, 35, 255-258.



- Jalota, S. (1973). Manual of Directions for the General Mental Ability Test. The Psycho-Centre, New Delhi.
- Jalota, S. (1976). General Mental Ability Test. The Psycho-Centre, New Delhi.
- Joshi, J.N. (1970). The Development of Algebraic Concepts during Secondary School Years. Ph.D. Thesis, Punjab University, Chandigarh.
- Joyce, D.E. (1977). A Study of Formal Reasoning in Elementary Education Majors. *Science Education*, 61, 2, 153-158.
- Juraschak, J.L. (1975). The Performance of Prospective Teachers on Certain Piagetian Tasks. Dissertation Abstract International, 35, 9, 3989A.
- Karplus, H. & Arons, A.S. (1976). Implication of Accumulating Data on Levels of Intellectual Development. *American Journal of Physics*, 44, 4, 396.
- Karplus, H. et al. (1973). Intellectual Development Beyond Elementary School I: Inductive Logic. The University of California, Berkeley, California.
- Karplus, H. & Karplus, J.W. (1970). Intellectual Development Beyond Elementary School I: Deductive Logic. *School Science and Mathematics*, 70, 398-406.
- Keating, D.P. (1975). Precocious Cognitive Development at the Level of Formal Operations. *Child Development*, 46, 276-280.
- Keating, D.P. & Caramazza, A. (1975). Effects of Age and Ability on Syllogistic Reasoning in Early Adolescence. *Developmental Psychology*, 11, 6, 837-842.



- Kozka, J. (1955). *Developmental Psychology: A Study of the Child's Mind*. New York: Holt, Rinehart & Winston.
- Kelley, T.L. (1928). *Intelligence in the Child of Man*. Stanford University Press, Stanford, California.
- Thun, H. (1976). Relation of Two Piagetian Stage Tests to IQ. *Developmental Psychology*, 12, 2, 102-107.
- Koffka, E. (1933). Principles of Gestalt Psychology. Harcourt, Brace & World, New York.
- Kohlberg, L. & Gilligan, L. (1971). The Adolescent as a Philosopher: The Discovery of the Self in a Post Conventional World. *Daedalus*, 100, 4, 1051-1055.
- Kohler, W. (1943). *Gestalt Psychology*. Liver-right, New York.
- Lawson, J.E. (1975). Sex Differences in Concrete and Formal Reasoning Ability as Measured by Manipulative Tasks and Written Tasks. *Science Education*, 59, 3, 397-405.
- Lawson, J.E. (1976). Formal Operations and Field Independence in a Heterogeneous Sample. *Perceptual and Motor Skills*, 42, 981-982.
- Lawson, J.E. (1977). Relationships Among Performances on Three Formal Operations Tasks. *The Journal of Psychology*, 96, 333-341.
- Lawson, J.E. & Miles, M.C. (1976). Concrete and Formal Thinking Abilities in High School Biology Students as Measured by Three Separate Instruments. *Journal of Research in Science Teaching*, 13, 3, 227-235.
- Lawson, J.E. & Renner, J.W. (1974). A Quantitative Analysis of Responses to Piagetian Tasks and its Implications for Curriculum. *Science Education*, 58, 4, 545-559.



- Townson, V. & Rimmer, J. (1975). Relationship of Science Subject Matter and Developmental Levels of Learners. *Journal of Research in Science Teaching*, 12, 4, 347-358.
- Lee, L. (1971). The concomitant development of cognitive and moral levels of thought : a test of selected predictions of Piaget's Theory. *Genetic Psychology Monographs*, 83, 93-146.
- Kangel, R. & Shuell, J. (1972). Exclusion of Irrelevant Factors : The Pendulum Problem. *Science Education*, 56, 66-70.
- Irwin, R. & Levine, R. (1976). Adolescent Reasoning : The Development of the Ability to Control Variables, "Advancing Education Through Science Education Programmes". Report 170. D Lawrence Hall of Science, Berkeley.
- Longoot, P. (1963). Analyse Statistique De Trois Tests Genetiques. *Revue de l'Institut National de la Recherche Pédagogique*, 4, 310-337.
- Lovell, K. (1961). A Follow-up Study of Inhelder and Piaget's : The Growth of Logical Thinking. *British Journal of Psychology*, 52, 143-153.
- Lovell, K. (1972). Developmental Processes in Thought. In *Intelligence in the Young Child and Its Development* (Collected writings) Edited by Ellen Willmott, The Macmillan Co., New York, 100-116.
- Lovell, K. & Butterworth, J. (1966). Abilities Underlying the Understanding of Proportionality. *Mathematics Teaching*, 37, 8-9.
- Lovell, K. & Ogilvie, J. (1977). Conservation of Substance : Growth of Conservation Volume. In The Essential Piaget, *ibid.*
- MacArthur, G. (1968). Some Differential Abilities of Northern Canadian Native Youth. *International Journal of Psychology*, 3, 43-51.





- Martel, M.J. (1974). An Analysis of Piaget's Logical-Mathematical Model for the Period of Formal Operations. Dissertation Abstracts International, 33(2), 3742.
- Martoreano, S.C. (1977). A Developmental Analysis of Performance on Piaget's Formal Operations Tasks. *Developmental Psychology*, 13, 6, 666-672.
- McKinnon, J. & Renner, J. (1971). Are Colleges Concerned with Intellectual Development. *American Journal of Physics*, 39, 1047-1052.
- Mealings, H.J. (1961). Some Aspects of Problem Solving in Science. M.A. Thesis, Institute of Education, University of Birmingham.
- Meeks, G. & Meeks, V. (1971). The Development of Formal Thought as Shown by Application of the Oscillations of a Pendulum: Application Study, Adolescence, 6, 219-233.
- Mills, L.R. & Dean, P.M. (1959). Problem Solving Methods in Science Teaching. Temporary Monograph, Bureau of Publications, Teacher's College, Columbia University, New York.
- Hodgill, T. and Celia (1974). Piagetian Research Compilation and Commentary Volume No. 3. NFAH Publication Co. Ltd., Windsor Berks.
- Nie, N.H. et al. (1970). Statistical Packages for the Social Sciences. McGraw-Hill Book Company, New York, 110-210.
- Nordland, et al. (1974). A Study of Levels of Concrete and Formal Reasoning Ability in Disadvantaged Junior and Senior High School Science Students. *Science Education*, 50, 4, 569-575.
- Osicki, K.J. (1973). Affective and Cognitive Development: Comparison of Need Achievement and Risk Level with Piagetian Levels of Cognitive Development for Two Socio-Economic Groups. Dissertation Abstracts International, 34, 6, 3152-3153.



- Paterson, D.G. et al. (1930). Minnesota Mechanical Ability Tests. Minnesota University Press, Minneapolis.
- Peel, J.A. (1960). The Pupil's Thinking. Old Bourne, London.
- Peel, J.A. (1966). Psychology and the Teaching of Science. British Journal of Educational Psychology, Nov.66.
- Piaget, J. (1926). Judgement and Reasoning in the Child. Harcourt, Brace & World, New York.
- Piaget, J. (1950). The Psychology of Intelligence. International Universities Press, New York.
- Piaget, J. (1951). Play, Dreams and Imitation in Childhood. Norton, New York.
- Piaget, J. (1952). The Origins of Intelligence in Children. International Universities Press, New York.
- Piaget, J. (1954). The Construction of Reality in the Child. Basic Books, New York.
- Piaget, J. (1962). The Language and Thought of the Child. Kegan Paul, London.
- Piaget, J. (1967). Biology and Knowledge. University Chicago Press, Chicago.
- Piaget, J. (1970a). Genetic Epistemology. Columbia University Press, New York.
- Piaget, J. (1970b). Science of Education and the Psychology of the Child. Orion, New York.
- Piaget, J. (1972). Intellectual Evolution from Adolescence to Adulthood. Human Development, 15, 1-12.



- Piaget, J. & Inhelder, B. (1977). Conservation of Substance, Weight and Volume. In The Essential Piaget, ibid.
- Rajput, M.D. (1975). A Study of the Scheme of Proportion Among Certain Groups of Adolescent Pupils. Unpublished M.Ed. Thesis, Bhopal University, Bhopal.
- Raven, J.C. (1973). The Development of A Test of Piaget's Logical Operations. Science Education, 57, 3, 377-385.
- Reaner, J. L. & Stafford, D.G. (1972). Teaching Science in the Secondary School. Harper & Row, New York.
- Ross, H.J. (1973). Some Empirical Parameters of Formal Thinking. Journal of Adolescence, 167-177.
- Roze, J. L. (1960). A Synthesis of Experimental Designs in Program Research. Journal of General Psychology, 43, 295-303.
- Sandhu, T. S. (1978). An Analogy Between Piagetian Grouping of Thought and Group Theory in Algebra. Indian Educational Review, 13, 3, 81-85.
- Seyra, A. & Daniel, J.D. (1975). Piagetian Cognitive Development and Achievement in Science. Journal of Research in Science Teaching, 12, 2, 165-174.
- Schwarz, P.A. & Krug, M. (1972). Ability Testing in Developing Countries - A Handbook of Principles and Techniques. Praeger Publishers, London.
- Schwebel, M. (1975). Formal Operations in College Freshmen. Journal of Psychology, 91, 133-141.
- Shayer, M. (1979). Has Piaget's Construct of Formal Operational Thinking Any Utility? British Journal of Educational Psychology, 49, 265-276.



- Shaver, M. & Wylam, L. (1978). The Distribution of Piagetian Stages of Thinking in British Middle and Secondary School Children. II - 14 to 16 Year-Olds and Sex Differentials. *British Journal of Educational Psychology*, 48, 62-70.
- Comerville, J.C. (1974). The Pendulum Problem : Patterns of Performance Defining Developmental Stages. *British Journal of Educational Psychology*, 44, 3, 256-261.
- Spearman, C. (1927). The Abilitation of Man. Macmillan Co., New York.
- Staver, J.R. and Gabal, D.L. (1979). The Development and Construct Validation of a Group - Administered Test of Formal Thought. *Journal of Research in Science Teaching*, 16, 6, 535-544.
- Stephenson, W. (1931). Tetrad - Differences for Non-Verbal Subtests. Tetrad-Differences for Verbal Subtests. Tetrad-Differences for verbal Sub-tests Relative to Non-Verbal Subtests. *Journal of Educational Psychology*, 22, 167-183, 255-257, 334-350.
- Stephenson, W. (1955). The Study of Behavior. University of Chicago Press, Chicago.
- Stephens, W.B. et al. (1969). The Development of Reasoning, Moral Judgement and Moral Conduct in Retardates and Normals. Department of Health Education and Welfare, Temple University Philadelphia, Washington D.C.
- Thomson, G.H. (1931). The Factorial Analysis of Human Ability. Houghton Mifflin Co., New York.
- Thurstone, L.L. (1935). The Vectors of Mind. University of Chicago Press, Chicago.





- Thurstone, L.L. (1938). Primary Mental Abilities. Psychometric Monograph, 1, 121.
- Tisher, R.P. (1971). The Development of Some Science Concepts : A Replication of Piaget's Studies with Pupils in New South Wales Country High School. Unpublished B.A. (Hon.) Thesis, University of New England, Armidale, New Wales.
- Titchener, W.B. (1898). Postulates of a Structural Psychology. Philosophical Review, 7, 443-466.
- Tuddenham, R.D. (1970). A Piagetian Test of Cognitive Development. In J. Cockrill (Ed). On Intelligence. Methuen & Co. Ltd. London.
- Upadhyaya, G.P. (1973). A Study of Intellectual Development and its Relationship with Intelligence and Achievement of 10th Grade Science pupils. Unpublished M.A. Dissertation, University of Rajasthan, Jaipur.
- Vaidya, N. (1964). A Study of Problem Solving in Science Among Certain Groups of Adolescent Children. M.A. Thesis Institute of Education, London.
- Vaidya, N. (1968). Problem Solving in Science. G. Chand & Co. New Delhi.
- Vaidya, N. (1971). The Impact Science Teaching. Oxford, & IBP Publishing Co., New Delhi.
- Vaidya, N. (1974). How Children Discover Knowledge. Oxford, IBP Publishing Co., New Delhi.
- Vaidya, N. (1975). A Study of some Aspects of Thinking Among Science Students of Adolescent Age. Ph.D. Thesis, University of Rajasthan, Jaipur.



- Vaidya, N. (1979). The Growth of Logical Thinking in Science During Adolescence. Oxford & Delhi Publishing Co., New Delhi.
- Vaidya, N. & Misra, H.M. (1975). The Role of Hypotheses in Solving Problems of Science. *The Rajasthan Board Journal of Education*, 11, 4, 1-10.
- Vaidya, N. & Tandon, T.C. (1978). Rump Effect as Observed during Problem Solving. *Educational Trends*, 13, 2, 39-62.
- Valentine, M. (1975). Performance on two Reasoning Tests in Relation to Intelligence, Divergence and Interference Awareness. *British Journal of Educational Psychology*, 45, 198-205.
- Vernon, P.E. (1961). The Structure of Human Abilities. Methuen & Co., Ltd. London.
- Vinacke, J. (1962). The Psychology of Thinking. Macmillan Publishing Co., New York.
- Waite, J.B. (1975). A Study Comparing College Science Students' Performance on Piagetian Type Tasks, Including Cross-Cultural Comparisons. *Dissertation Abstracts International*, 35, 9, 8954 A.
- Walker, R.A. et al. (1979). Written Piagetian Task Instruments: Its Development and Use. *Science Education*, 63, 3, 211-230.
- Watson, J.B. (1913). Psychology as the Behaviourist Views It. *Psychological Review*, 20, 3, 155-177.
- Watson, J.B. (1944). Behaviourism. Norton, New York.
- Weeks, R.T. (1973). The Relationship of Grade, Sex, Socio-economic Status, Scholastic Aptitude and School Achievement to Formal Operations Attainment in a Group of Junior High School Students. *Diss. Abst. International*, 34, 5-A, 2405.



- Wertheimer, M. (1923). Laws of Organization in Perceptual Forms (Translated and condensed) In J.D.Allis, A Source Book of Gestalt Psychology. Harcourt, Brace & World, New York, 1938.
- Wertheimer, M. (1945). Productive Thinking. Harper & Row, New York.
- Wosny, C.J. (1974). The Effects of Culture and Education on the Acquisition of Formal Operational Thinking. Dissertation Abstracts International, 34, 7, 4015.
- Wosny, C.J. & Cox, D.L. (1975). The Effects of Task Differences on the Assessment of Formal Operational Thinking. Paper Presented at the Annual Meeting of the American Educational Research Association, Washington, D.C.
- Yudin, L. (1966). Formal Thought in Adolescence as a Function of Intelligence, Child Development, 37, 697-708.
- Yudin, L. (1967). The Nature of Adolescent Thought. Adolescence, 2, 137-151.



# WINDOZ





APPENDIX (i)

Test of Piaget Type Tests

Part I

Time : 45 Min.

Name of the Student

.....

Boy or Girl

.....

Father's Name

.....

Name of the School

.....

Class

.....

Section

.....

Roll No.

.....

Date

.....



## TASK NO. 1

A gardener gave a bunch of flowers of different types to his son and asked him to classify the flowers into different groups. The boy put the roses in one group, cherrilli in the other and so on. Then the gardener asked him to further sub-classify the roses into different categories. The boy put the red roses in one category, the white roses in the other and so on. Now you go through the task given ahead and try to perform as demanded.

Here are given some geometrical figures on the next page (Fig. 1). Each figure has been assigned a number for its identification. Classify those figures into three main categories in such a way that similar figures come under one category. You are to write only the numbers of the figures under the categories I, II and III to which they belong:

Category I

Category II

Category III

Now, further sub-classify each category into three sub-categories in such a way that similar figures of each category come under the three sub-categories of the same:

Category I  
sub-categories  
A    B    C

Category II  
sub-categories  
A    B    C

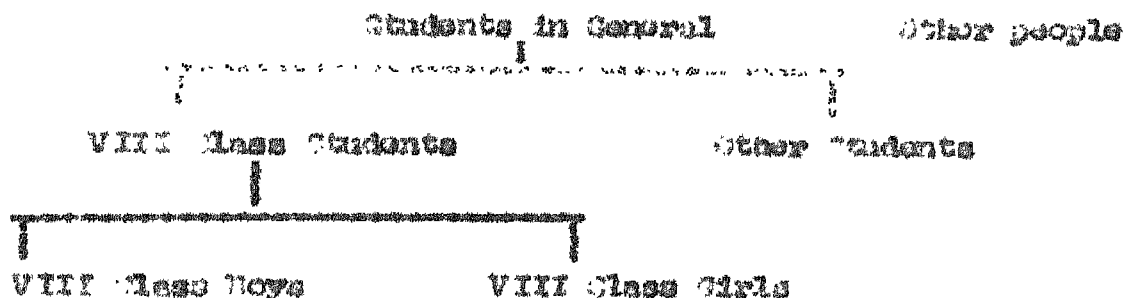
Category III  
sub-categories  
A    B    C



# TABLE NO. 3

Look through the Classification Hierarchy given below (Fig. 3) and with the understanding of it answer the questions given ahead.

Fig. 3



1. If VIII class boys and VIII class girls are grouped together, what name will you give to the group formed? \_\_\_\_\_
2. If VIII class boys are grouped with VIII class students and then both in VIII class are grouped with students in general, what name will you give to the group formed? \_\_\_\_\_
3. If VIII class students are grouped with students in general and then both in combination are grouped with VIII class boys, what name will you give to the group formed? \_\_\_\_\_
4. If VIII class boys are grouped with a class without students, what name will you give to the group formed? \_\_\_\_\_
5. If VIII class boys are grouped with VIII class girls and then VIII class boys are taken out from the group, what name will you give to the group left behind? \_\_\_\_\_
6. If VIII class boys are grouped with VIII class boys, what name will you give to the group formed? \_\_\_\_\_
7. If VIII class boys are grouped with VIII class students, what name will you give to the group formed? \_\_\_\_\_



## PART III, 3

Three sets of numbers and algebraic symbols having two columns each are given below (Fig. 3). In each set you will find some relationship between the entities of the two columns. Try to understand the relationship and fill in the blanks given in each set :

Fig. 3

1	2	3
2 $\rightarrow$ 8	$-7 \rightarrow -12$	$5 \times 2 = 10$
6 $\rightarrow$ 9	$-13 \rightarrow -18$	$5 \times 3 = 15$
10 $\rightarrow$ 13	$-19 \rightarrow -24$	$5 \times ( ) = 20$
14 $\rightarrow$ ( )	$-25 \rightarrow ( )$	$( ) \times 5 = 25$
( ) $\rightarrow$ ( )	$( ) \rightarrow ( )$	$( ) \times ( ) = ( )$
$\lambda \rightarrow \lambda + 3$	$-\lambda \rightarrow -\lambda - 3$	$5 \times \lambda = 5\lambda$
$\lambda + 4 \rightarrow \lambda + 7$	$-\lambda - 6 \rightarrow -\lambda - 11$	$5 \times (\lambda + 1) = 5\lambda + 5$
$\lambda + 8 \rightarrow ( )$	$-\lambda - 13 \rightarrow ( )$	$5 \times ( ) = ( )$
( ) $\rightarrow$ ( )	$( ) \rightarrow ( )$	$( ) \times ( ) = ( )$
( ) $\rightarrow$ 11	$( ) \rightarrow -15$	$5 \times ( ) = 15$
( ) $\rightarrow$ ( )	$( ) \rightarrow ( )$	$( ) \times ( ) = ( )$

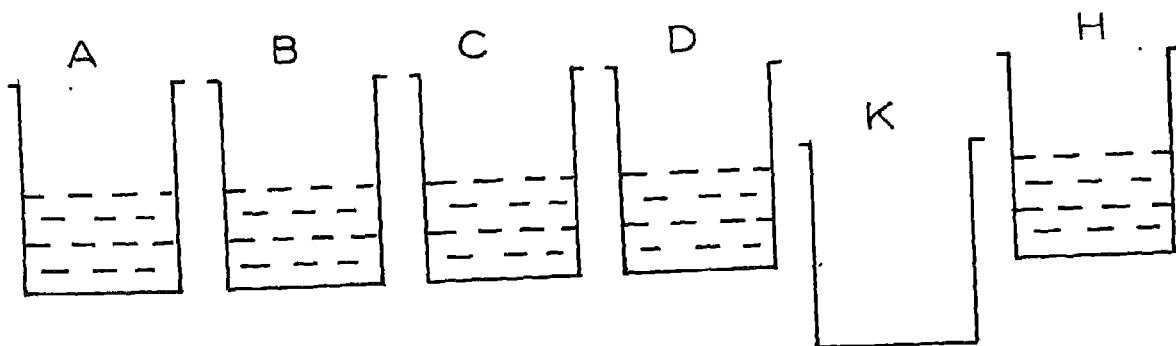




## TASK (P). 4

Four beakers A, B, C and D are placed on a table (Fig. 4). The fifth beaker E is placed a bit away. All the beakers are filled up with different chemical reagents. There is one empty beaker K. You have performed an experiment with these chemicals one day. You took out the chemical reagent from some of the A, B, C and D beakers and put into the beaker E. Then he took out the reagent from beaker E and put it also into the beaker K. Thus, the contents of the beaker E became yellow in colour. What experiments will you perform to find out the reagents which on putting together have made the yellow colour appear? Describe all possible experiments.

Fig. 4



## Examples:

## Experiment No. 1

Took out the chemical reagent from the beaker A and put it into the empty beaker K. Then took out the chemical reagent from the beaker B and put it also into beaker K.

## Experiment No. 2

Took out the chemical reagents from the beakers B and C and put them into the empty beaker K. Then took out the chemical reagent from the beaker D and put it also into the beaker K.

Similarly, you write down the other possible experiments.



Experiment No.

Experiment No.

Experiment No.

Experiment No.

Experiment No.

Experiment No.

Experiment No.

Experiment No.

Experiment No.

Experiment No.

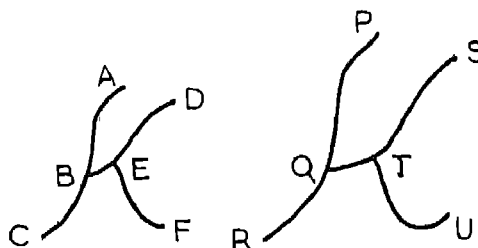
Experiment No.



## PART II. 5

A letter "T" is given (Fig. 3) in two different sizes - one small and the other large. It is given that the lengths of the arms of the small letter and the large letter are in the ratio of 2:3. On the basis of this information answer the questions given below:

Fig. 3



1. If length of the arm AD is 4 cms., what will be the length of the arm EF? \_\_\_\_\_
2. If length of the arm PQ is 8 cms., what will be the length of the arm ST? \_\_\_\_\_
3. If length of the arm AB is 16 cms., what will be the length of the arm PQ? \_\_\_\_\_
4. If length of the arm BC is 10 cms., what will be the length of the arm QR? \_\_\_\_\_
5. If length of the arm DE is 9 cms., what will be the length of the arm ST? \_\_\_\_\_



APPENDIX (11)

Test of Piaget Type Tasks

Part II

Time : 45 min.

Name of the Student

\_\_\_\_\_

Boy or Girl

\_\_\_\_\_

Father's Name

\_\_\_\_\_

Name of the School

\_\_\_\_\_

Class

\_\_\_\_\_

Section

\_\_\_\_\_

Roll No.

\_\_\_\_\_

Date

\_\_\_\_\_





## TATT NO. 6

The children of your age are very curious to know about the things in their environment. Number of questions come to their minds whose answers they do not know. For example, Mohan, a child of your age asked the following questions about the Sun:

1. Is <sup>the</sup> Sun a ball of fire in reality ?
2. Why the Sun does not fall on the Earth ?
3. Can we live without <sup>the</sup> Sun ?
4. What is the temperature of the Sun ?

Thus many questions might have been coming to your mind also. You please write down as many questions as you can whose answers you do not know, about (a) Bicycle, and (b) Cow.

(a) Bicycle

(b) Cow

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....



## TASK NO. 7

There is given a board having traced nine squares upon it (Fig. 6). The top three squares (A,B,C) were painted blue, the middle three squares (D,E,F) were painted white and the bottom three squares (G,H,I) were painted red. When they were painted second time it so happened that the left three squares (A,D,G) got painted red, the middle three squares (B,E,H) got painted blue and the right three squares (C,F,I) got painted white. Thus, the different colours got mixed and changed in the various squares as follows:

1. The square which was painted blue and red or vice-versa looked gray in colour.
2. The square which was painted blue and white or vice-versa looked light blue in colour.
3. The square which was painted red and white or vice-versa looked pink in colour.

You please write down the name of the colour in each square of which it looked like after the two paints.

Fig. 6

A	B	C
D	E	F
G	H	I



## PART III. B

Sam asked Mohan what are the factors upon which depends the drying up of a wet handkerchief? Mohan told him that this question could have many answers such as :

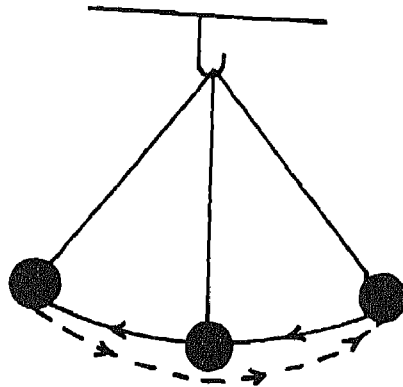
1. Nature of the stuff, i.e., cotton, silk, etc.
2. Length
3. Thickness
4. Colour
5. Temperature
6. Season, etc.

Then Sam asked Mohan to prove the effect of these factors with the help of the experiments. Mohan suggested as follows:

Suppose I am to prove that the drying up of a wet handkerchief depends upon the length of it. I shall take three handkerchiefs of the same stuff, same thickness, same colour, etc., but with different lengths only. I shall moisten them equally wet and put them in the sun or shade. The time taken by each handkerchief to dry up will be noted with the help of a watch. If the handkerchief having the smallest length dries up first and the one having the largest length dries up at the last then it is proved that the drying up of a wet handkerchief depends upon the length of it, otherwise not. Similarly, the effect of the other factors can be proved through the experiments. Now you please solve the problem given ahead:



Fig. 7



A simple pendulum is shown in the Fig. 7 above. The bob of the pendulum oscillates on both sides of the centre. The movement of the bob from the centre to <sup>the</sup> left end, back to the centre, then to the right end and back to the centre is called the one oscillation of the pendulum. You please write down the factors upon which depends the time taken in one oscillation of the pendulum and prove the effect of each factor through experiments.

- Factors :
1. \_\_\_\_\_
  2. \_\_\_\_\_
  3. \_\_\_\_\_
  4. \_\_\_\_\_
  5. \_\_\_\_\_





Experiment No.

1. The purpose of this experiment is to determine the effect of temperature on the rate of reaction between hydrogen peroxide and potassium iodide. The reaction is as follows:

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

The rate of reaction is measured by the volume of oxygen gas produced over a period of time. The experiment is carried out at three different temperatures: 20°C, 30°C, and 40°C. The results are shown in the table below:

Experiment No.

2. The purpose of this experiment is to determine the effect of concentration on the rate of reaction between hydrogen peroxide and potassium iodide. The reaction is as follows:

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

The rate of reaction is measured by the volume of oxygen gas produced over a period of time. The experiment is carried out at three different concentrations of hydrogen peroxide: 0.5M, 1.0M, and 1.5M. The results are shown in the table below:

Experiment No.

3. The purpose of this experiment is to determine the effect of catalyst on the rate of reaction between hydrogen peroxide and potassium iodide. The reaction is as follows:

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

The rate of reaction is measured by the volume of oxygen gas produced over a period of time. The experiment is carried out with and without a catalyst (potassium iodide). The results are shown in the table below:

Experiment No.

4. The purpose of this experiment is to determine the effect of surface area on the rate of reaction between hydrogen peroxide and potassium iodide. The reaction is as follows:

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

The rate of reaction is measured by the volume of oxygen gas produced over a period of time. The experiment is carried out with and without a catalyst (potassium iodide). The results are shown in the table below:

Experiment No.

5. The purpose of this experiment is to determine the effect of pH on the rate of reaction between hydrogen peroxide and potassium iodide. The reaction is as follows:

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

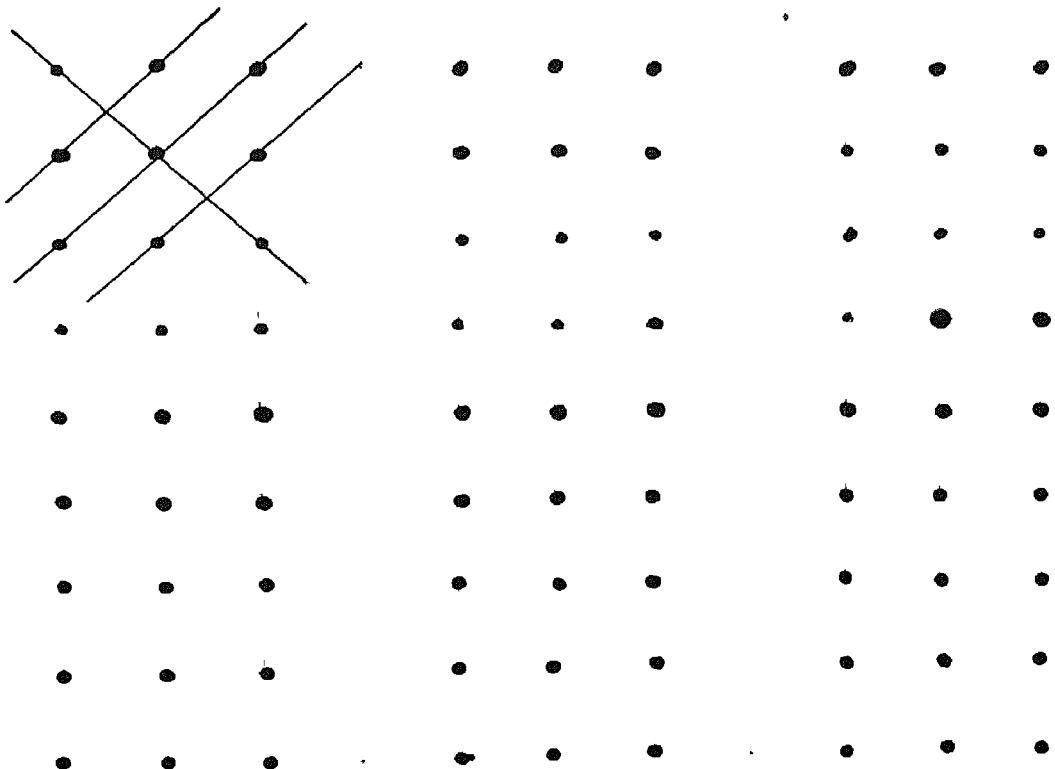
The rate of reaction is measured by the volume of oxygen gas produced over a period of time. The experiment is carried out at three different pH values: 3, 7, and 11. The results are shown in the table below:



## PART NO. 9

A number of sets of nine dots are given below (Fig. 8). You please try to draw four straight lines in such a way that all the nine dots are touched by one or the other line. Repeat this exercise with as many different ways as you can but the number of lines should not exceed four and no dot should remain untouched.

Fig. 8





# TEST NO. 10

Read, understand and then answer the questions given below:

1. There is a 10 metre long rod of wood out of which 1 metre rod is cut after every minute. In much time will it take to be cut into pieces of 1 metre length each?

.....

2. Some ducks are swimming in a pond in a straight line. Two ducks are on the front side, two in the middle and two on the backside. How many ducks are there in all?

.....

3. Ram has four friends. Three of his friends are having names as Bryan, Mohan and Chit. What is the name of the fourth friend?

.....

4. There is a blind man. He can see upto 100 metres through one eye. How far will he be able to see through both the eyes?

.....

5. A donkey has two horns. How many horns will be having eight donkeys?

.....



## APPENDIX ( III )

REPRINTED FROM INDIAN EDUCATIONAL REVIEW JULY 1978 1990/1

### An Analogy between Piagetian Grouping of Thought and Group Theory in Algebra

TEG SINGH SANDHU

*Junior Research Fellow  
Examination Research Unit  
NCERT, New Delhi*

It was in 1920, that J. Piaget, while working with Dr. Theophile Simon in Paris, to develop a standardized test, found that the children's incorrect answers were fascinating. He found that the same wrong answers occurred frequently in children of the same age. From the analysis of the nature of the mistakes, he came to the conclusion that older children were not only just brighter than younger ones, but also the thought of younger children was qualitatively different from that of older ones. On the basis of the quality of the responses at different age level, Piaget divided intellectual development into four major periods : (i) Sensorimotor period (0 to 2 years) ; (ii) Pre-operational period (2 to 7 years) ; (iii) Concrete operational period (7 to 11) years ; and (iv) Formal operational period (11 years and above). The characteristics of these four stages are given below

#### *1. Sensorimotor Period (0 to 2 Years)*

During this period language appears and symbolic functioning makes its acquisition possible.

#### *2. Pre-Operational Period (2 to 7 Years)*

This was further sub-divided into two periods : (a) Ranging from (2 to 5 years), and (b) Ranging from (5 to 7 years).

At the stage (a) the child fails to construct hierarchical arrangements because after a short while he forgets the defining property which he has used to form a collection. At the stage (b) the child can construct a hierarchy because he can use a defining property to determine which





objects go in a collection. But he cannot understand inclusion relations

### *3. Concrete Operational Period (7 to 11 Years)*

At this stage, concrete operations are organized. Operational grouping of thought concerning objects can be manipulated or known through senses. Child can correctly answer questions concerning inclusion, because of his ability to think of original classes and their derivatives at the same time. But the child fails to comprehend the same relations when imaginary classes are involved.

### *4. Formal Operational Period (11 Years and above)*

At this stage, actions are internalized. The child can operate on operations. He can compensate mentally for transformations in reality. Mental operations have reached a high degree of equilibrium thus effecting a second degree grouping of operations.

From the above mentioned characteristics it becomes clear that 'grouping of thought' starts at the third stage of development of intellect. Our further discussion, primarily, will be focussed on the third stage, i. e. concrete operational period.

Let us now see both the terms 'operation' and 'grouping' from the point of view of logicians as well as psychologists, to compute the similarities between the two viewpoints. According to psychologists operation means to arrive at a real functioning of intelligence or to revert the thinking in terms of actions. While according to logicians or mathematicians 'operation' means a symbol, representing an action which could be realized.

Analysis of a mathematical nature has since long recognized the interdependence of operations, constituting certain well defined systems, such as groups. The notion of a 'group' is applied to series of whole numbers, to spatial or temporal structures, to algebraic operations, etc. Psychologically, a 'grouping' consists of a certain form of equilibrium of operations, i. e. actions which are internalized and organized in complex structures and the individual is to describe this equilibrium.

### *Group Theory and Piagetian Grouping of Thought*

The important question here is to determine the conditions of the



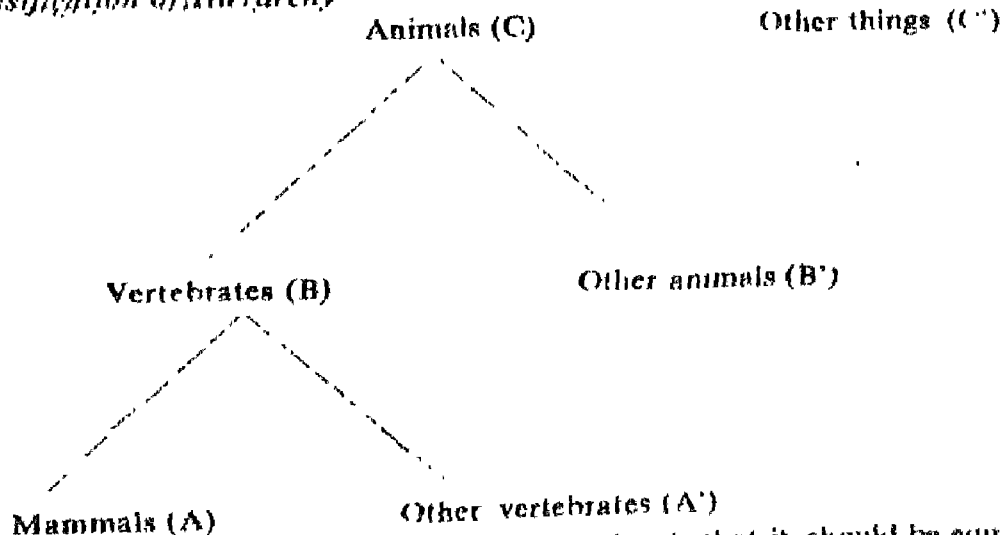
equilibrium (i.e. mobile equilibrium, since operations are actions, the equilibrium of operational thought is in no way a state of rest) in order to be able subsequently to examine how it is formed genetically. These conditions are four in number in the case of a group of mathematical order and five in the case of grouping of a qualitative order. We can make a comparative study of the two types of orders as follows :

In mathematics, a set  $G$  equipped with a composition, denoted multiplicatively is called a group, if

- (i) Composition is associative, i.e.  
 $a(bc) = (ab)c \forall a, b \text{ and } c \in G.$
- (ii) There exists an identity for the composition, i.e.  
 $a \in G$ , there exists an element  $e, \in G$  such that  $a e = a = ea$
- (iii) Every element is inversible, i.e. for every element  $a \in G$  there exists an element  $b \in G$ , such that  $ab = e = ba.$

Taking each conditions separately we can compare it with the operations of 'grouping of thought'. For this purpose let us take an example of the sort of classification hierarchy of animals, which the children of the age of 7-11 years, or above can construct (according to Piaget's experiments).

*Classification of Hierarchy*



I. The first condition of a group in algebra is that it should be equipped with a composition, i. e. any two elements of a group may be combined and thus produce an element of the same group. This property is usually referred as closure.

I'. According to Piaget, this first condition expresses the possibility of



coordinating operations in 'grouping of thought', i. e. two distinct classes may be combined into one comprehensive class which embraces them both. For example, if we combine the mammals with other vertebrates we get the general class of vertebrates. This may be written as  $A + A' \rightarrow B$  or if we combine mammals with vertebrates we get all the vertebrates. We may write this as  $A + B \rightarrow B$ . This property describes aspects of the child's ability to understand a hierarchy. If he can mentally construct a large class by combining its sub-classes.

II. Second condition of the group is that composition is associative, i. e.

$$a(bc) = (ab)c \quad a, b, c \in G$$

II'. The property of associativity in 'grouping of thought' may well be illustrated from the given example of classification hierarchy.

Suppose we want to combine three classes such as mammals, vertebrates and animals, i. e. A, B and C. We cannot add all the three at a time, since the operator (combining) is binary, i. e. it can be applied only to two elements at a time. Therefore, there are at least two ways of adding A, B and C. *First*, We can add mammals to vertebrates and get vertebrates and then adding vertebrates to the animals we get animals in general, i. e.

$$i) (A + B) + C = C$$

*Second*, We can do by combining the mammals with the vertebrates of vertebrates and animals and finish with the same results, i.e. animals in general,

$$ii) A + (B + C) = C$$

From first and second, we get

$$(A + B) + C = A + (B + C)$$

Thus associativity expresses the fact that the child can combine classes in different orders and can realize that the results are equivalent.

III. The third condition of the group in algebra is that there exists an identity for the composition, i. e. for every element  $a$  belonging to  $G$ , there exists an element  $e$ ,  $\in G$  such that

$$ae = a = ea$$

III'. In the child's classification of 'grouping of thought' identity states that there is a special element in the system (the 'nothing' element) which when combined with any of the other elements produces no change. From our example, cited before, if we combine to 'nothing' element with mammals, the result will be mammals. More correctly, if we do not combine the mammals with any of the other classes, then of course we still have the mammals.



IV. The fourth condition of the group is that every element is invertible, i. e.

$$ab = e \Rightarrow ba \quad \forall a, b, e \in G$$

IV'. The reversibility in 'grouping of thought' can be illustrated from the given example. Suppose we combine the mammals with all other vertebrates, we get all vertebrates. But if we take away inverse or negation of all the other vertebrates except mammals then again we are left with mammals. This type of operation expresses the aspect of class inclusion. Such a reasoning underlies the child's ability to say that there are more vertebrates than mammals, i. e. mammals are more included in the class of vertebrates.

V. The fifth property of 'grouping of thought' is unique. It has several aspects. One of them has to do with special identity elements. Suppose we combine the class of mammals with itself, the result is mammals. We may write this as :

$$A + A = A$$

In this equation A functions as an identity element. Piaget calls this a tautology. Another aspect is resorption. If we combine the class of mammals with the class of vertebrates the result is vertebrates. We may write this :

$$A + B = B$$

Here too, A functions as an identity element. In a sense, this is another way of looking at inclusion relations.

These are some of the aspects of grouping, described by the processes underlying the child's classifications.

#### REFERENCES

- GINSBURG HERBERT and SYLVIA OPPER, *Piaget's Theory of Intellectual Development*, Prentice-Hall, Inc., New Jersey, 1969
- PIAGET, J., *Judgment and Reasoning in the Child*, Trans. M. Warden, New York, Harcourt, Brace & World, Inc., 1926
- , *The Psychology of Intelligence*, Routledge & Kegan Paul Ltd., London
- , *The Origins of Intelligence in Children*, Trans. M. Cook, International University Press, New York, 1952
- SILANTI NAKAYAN, *A Textbook of Modern Abstract Algebra*, S. Chand & Co., 1967





# APPENDIX (iv)

## Table Chart of Variables

<u>Cr. No.</u>	<u>Code</u>	<u>Variable</u>
1.	IV	Intelligence verbal
2.	IV	Intelligence non-verbal
3.	IX	Adjustment
4.	C A	Reserved/Outgoing
5.	T B	Concrete thinking/Abstract thinking
6.	E J	Emotionally less-stable/Emotionally stable
7.	Q D	Phlegmatic/Excitable
8.	I A	Obedient/Assertive
9.	I C	Cautious/Reckless
10.	E B	Dependent/Conscientious
11.	Q I	Shy/Adventurous
12.	Q I	Tough-minded/Tender-minded
13.	I B	Jealous/Circumspect
14.	I D	Secure/Insecure
15.	I B <sub>2</sub>	Group-dependent/Self-sufficient
16.	I B <sub>3</sub>	Uncontrolled/Self-disciplined
17.	I B <sub>4</sub>	Relaxed/Tense
18.	Q I	Space relations
19.	Q I	Reasoning ability
20.	Q I	Classification
21.	Q I	Grouping of thought
22.	Q I	Generalization to arithmetical and algebraic symbols.
23.	Q I	Permutations and combinations
24.	Q I	Ratio and proportion
25.	Q I	Formulation of probing questions
26.	Q I	Interpretation and coordination of information
27.	Q I	Stating and testing hypotheses
28.	Q I	Space visualisation
29.	Q I	Grasping the essence of the problem
30.	Q I	Academic achievement in Maths.
31.	Q I	Academic achievement in Science.
32.	Q I	Academic achievement in English
33.	Q I	Academic achievement in Punjabi
34.	Q I	Academic achievement in Hindi



# APPENDIX (V)

Educational Trends

Volume 13, No. 2, July, 1978

## **Lump Effect as Observed During Problem Solving**

**T. S. Sandhu**

Regional College of Education,  
Ajmer

**N. Valiya**

Regional College of Education,  
Ajmer

### **Background**

By its very nature, the investigation of human thought right from infancy to adulthood is a complex venture. Its experimental investigation through the techniques of problem solving is of recent origin. Problem solving takes place as soon as the problem is perceived by the problem solver and is aimed at to reach the goal. The problem is supposed to be not only new and novel but also at the same time, there is supposed to be no direct solution available to the problem solver at the time of its presentation. Moreover, according to K. Duncker (1945), it is also assumed that the problem solver possesses the needed information for solving it. Problem solving, as a technique of investigation, has been utilized very widely in research studies pertaining to the diversified range of conceptual schemes of thought in the fields of general psychology and the newly emerging literature on science education. When search for clarity is made, overall confusion intervenes when problem solving is defined as 'combining the essentials of two isolated experiences' Maier (1930) or as 'the integrated activity of perception, memory, recall, association, generalization and reconstruction of ideas' Welch (1972). Even when seen in its specific context, problem solving ability is said to vary very widely, for example, the 'simple finding of exceptions' Hazlitt (1930) at one end, to the 'formal reasoning of a complex nature' Inhelder (1960) at the other end. This bleak situation still further worsens when problem solving situations used to evoke thinking vary very widely. Examples are dogs, cats and rats in puzzle boxes and mazes as well as human beings solving advanced problems involving fundamental concepts of mass, length, space and time.

### **The Past Literature**

Past literature in this area can be classified in terms of studies in concept



formation, problem solving and when all lumped from the view point of teaching methodology, science education. Beard (1957), Hull et al (1961), Smoke (1961), Hausman and Kassanin (1961) and Iruner et al (1962) have investigated concept formation over the years but hardly any work seems to have been done on the evolution of concepts in relation to their functional and quantitative aspects. Heidebreder (1928), Maier (1930), Durkin (1937), Mumford (1937), Duncker (1945) Husell (1956), Wheeler (1958) and Vaidya (1964) have investigated the phenomenon of problem solving with widely different problems having clear cut solutions. Here, too, there is no consensus regarding the age at which formal reasoning begins. In the area of science education, Deustasche (1943), Oakes (1947), Kyle (1950), Szekely (1950), Kruglak (1951), Whellock (1953), Butt (1957), Banks (1958), Mealings (1961), Neal (1961), Stendler (1951), Carpenter (1963), Horton (1963), Muthulingam (1963), Peel (1965) and Vaidya (1971) have investigated problem solving in science from different standpoints, making in the process the comparison of findings stemming from the various studies impossible. Consequently, there is no sharp theoretical framework available for seeing varied researches on problem solving. Yet there is one net gain of this long term effort that any researcher in this area is in a position to know the kind of road yet to be travelled with a view to cut and stitch concepts for maximum educational development with minimum of effort and cost.

### **The Main Study**

It was undertaken to investigate certain aspects of thinking through the medium of problem solving among science students of adolescent age duly matched on intelligence and socio-economic status. One of its side aims was to study errors as they occur in solving a set of seventeen problems when presented individually in two sessions. These problems were mostly Piagetian in flavour and involved constant differences, summation, algebraic generalization, proportion, repeated structurings and restructurings, use of insight, proposing tests, combinational grouping, formulating problematic situations and stating as well as testing hypotheses.

### **Method of Procedure**

*Sample and subjects :* A sample of 200 students, 100 boys and 100 girls ranging from age (10.5 to 11.5) to (14.5 to 15.5) in years corresponding to the grades VI through X, was selected and matched on the basis of intelligence test and socio-economic status (Jalota and Kuppaswamy). Seventeen problems, each containing a continuous chain of reasoning, were administered individually in two sessions. These seventeen problems were further analysed in terms of thinking



processes, judged necessary to solve these problems which were later on reclassified into seventeen schemes of thought. Coefficients of reliability and validity for the entire problem solving test were determined which, according to Guilford (1956), were found to be within the range of acceptable limits.

#### **Noticing the Hump Effect**

It was observed that adolescent pupils have committed a large number of errors while engaged in the acts of problem solving. The dominant errors (shared by more than 20 percent of these pupils) were further found to increase with age before their frequency finally fell. It is of interest to highlight this finding because whereas understanding increased with age, the individual errors, contrary to expectations, too, appear to have suffered their ups and downs before finally declining with age. Why should it happen? Is it the case of an adolescent playing with figures thoughtlessly or arbitrarily in the hope of being favoured with good luck? Is it his care to respond to the varied test items in any manner he likes, regardless of consequences and meanings? Is it the case of lack of seriousness on his part? Is it his case of being caught between the horns of a dilemma and getting muck? Is it the case of hot chase trying hard to choose in haphazard directions as if in the manner of closing in on the problem? Does it illustrate that mastery of a thought process is through a path : uphill, thorny and often erratic? Or does the adolescent regress as if on an adventurous Piagetian journey during which he is trying hard to educate out himself, thinking that the right path to concept development lies in flourishing on experimental failures or a problem solving situation in which either understanding suffers a dip or errors a hump? Alternatively, is it a fact of rubbing his schemes of thought wrongly, especially when he has personal reservations about his self acquired knowledge in contrast to school learning which does not set right his firmly held self centred thoughts? Lastly is it the case that he chooses to be very romantic in his computations when confronted with a problem situation leading to a chaos? These are some of the stray notions which strike while having encountered this elusive phenomenon in several contexts :

- ( i ) When the answer to the test item is contained in the problem itself.
- ( ii ) When the test item needs an arithmetical or algebraic symbol.
- ( iii ) When the count is kept of total number of trials or errors on individual steps.
- ( iv ) When the same step is suggested again after having undertaken other steps in the furtherance of solution, namely, resting points.





- (v) Lastly, when the count is kept of total number of arbitrary as well as extraneous considerations brought into the problematic situation during problem solving.

### Illustrations of the Phenomenon

Selected data involving 'Hump Effect' are now presented in respect of certain thought processes where dominant errors on them undertook unusual courses.

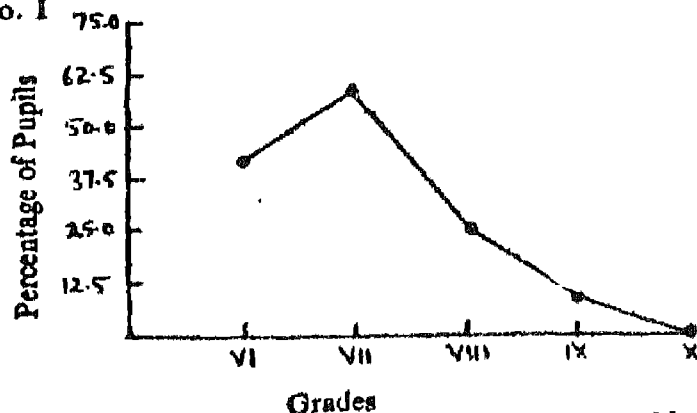
Table I

N=200

S. No.	Description of the Process	S. No of Problem & Process	Gradewise percentage of pupils committing errors				
			VI	VII	VIII	IX	X
1.	What is the height of Mohan ?	1(2)	40	57.5	25	10	0
2.	Generalization to Algebraic Symbol	2(13)	47.5	42.5	87.5	75	55
3.	What is the total distance when the man goes four times around the rectangle ?	6(37)	12.5	27.5	17.5	12.5	2.5
4.	Suppose a donkey has two horns. How many horns in all have eight donkeys ?	10(53)	27.5	20	42.5	52.5	37.5
5.	Beakers Problem	13	67.5	85	72.5	65	57.5
6.	What is the combined real depth of the fish when seen from above as well as from below ?	14(83)	12.5	25	20	42.5	5
7.	Proposing tests problem	16	35	47.5	62.5	27.5	2.5

Consider now the graphical illustrations of the data presented above.

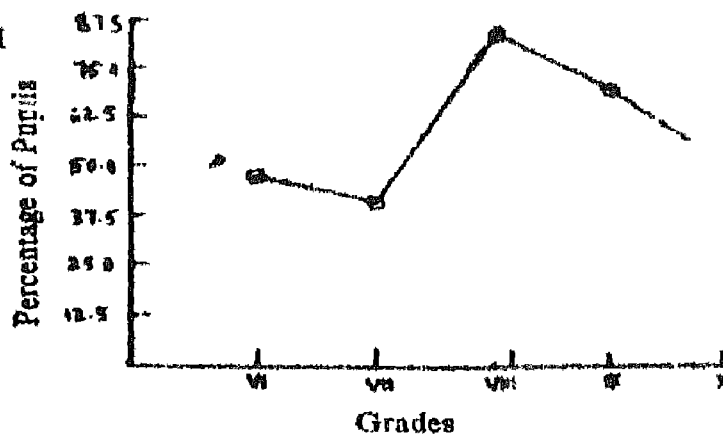
Fig. No. I



Hump of dominant error on process No. 2 of Problem No. 1

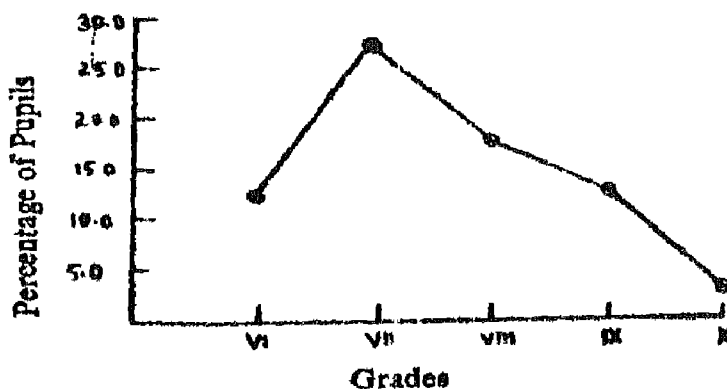


Fig. No. II



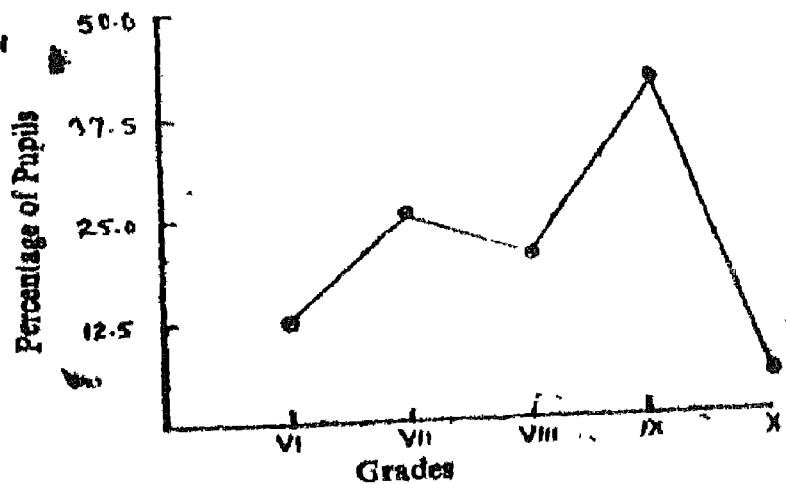
Hump of dominant error on Process No. 13 of Problem No. 2

Fig. No. III



Hump of dominant error on Process No. 37 of Problem No. 6

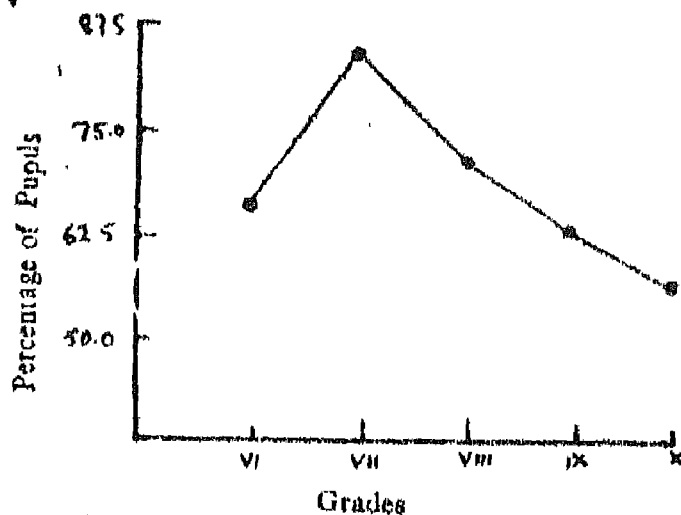
Fig. No. VI



Hump of dominant error on Process No. 63 of Problem No. 10

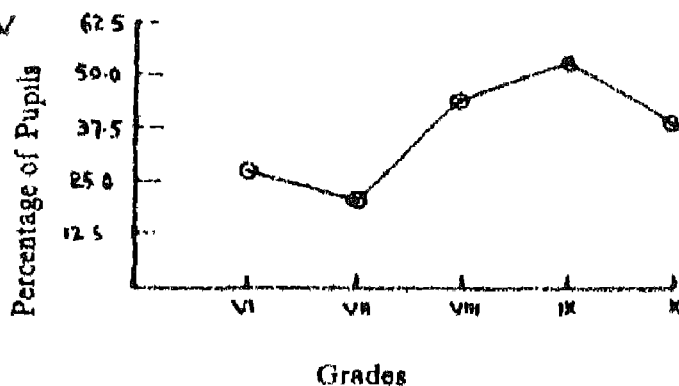


Fig. No. V



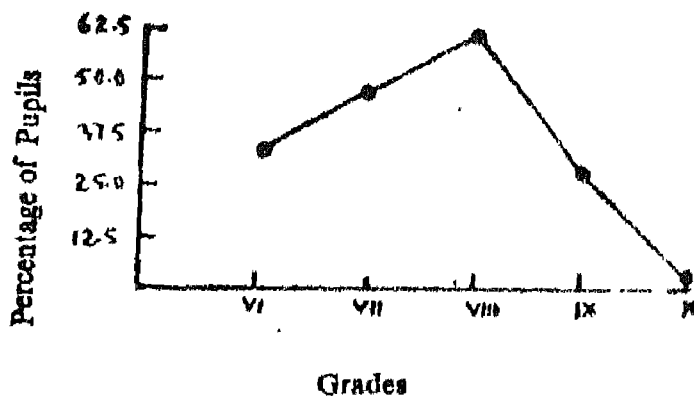
Hump on the incidence of arbitrary errors arising due to the failure to accept the demand of the problem No. 14

Fig No. IV



Bi-Hump of the dominant error on Process No. 83 of Problem No. 14

Fig. No. VII



Hump on the arbitrary errors arising due to the failure to grasp the essence of the Problem No. 16



## Hump Effect During the Mastery of Thought Processes

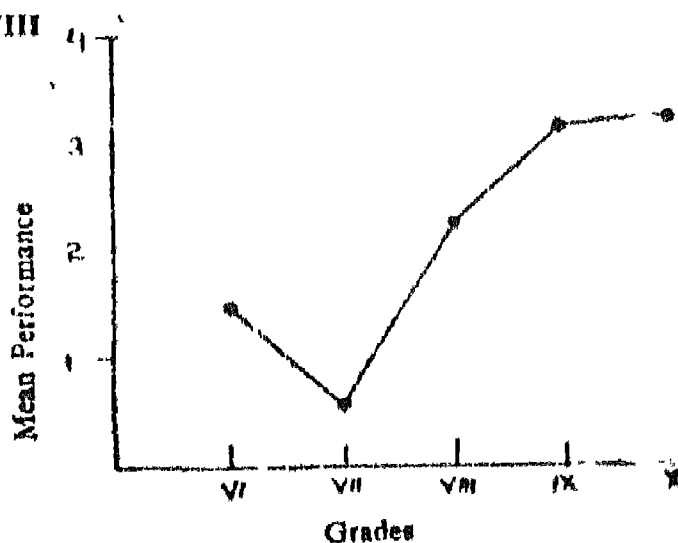
When data were further looked into, similar effect appeared, while the pupils were manifesting mastery on the various thought processes aggregated together as judged by their mean scores on respective problems. Data in the context are presented below :

Table II

S. No.	Description of the problem	S. No. of the Problem	Mean Scores at Different Grades				
			VI	VII	VIII	IX	X
1.	Height Problem	1	1.45	.53	2.25	3.13	3.20
2.	Digital Problem (Combinatorial)	9	2.67	2.45	5.35	5.40	7.78
3.	Formulating Questions Problem	12	5.67	9.13	7.40	9.65	11.48
4.	Fish Problem	14	.05	.28	2.56	2.30	4.90

Now consider another set of graphical illustrations, showing hump effect in another context on mean scores of problems as referred to above.

Fig. No. VIII

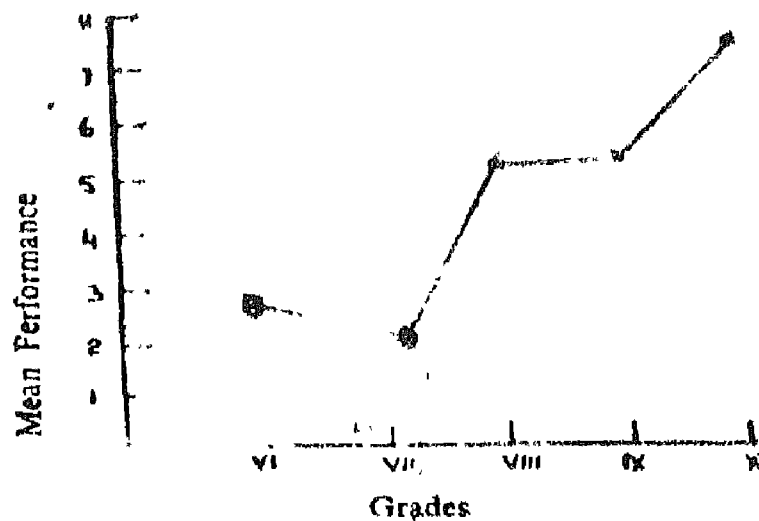


Hump in the mastery of thought processes on Problem No. 1



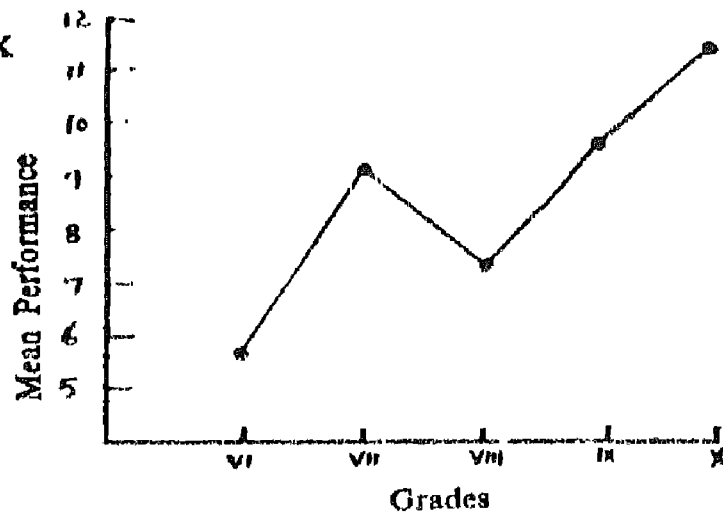


Fig. No. IX



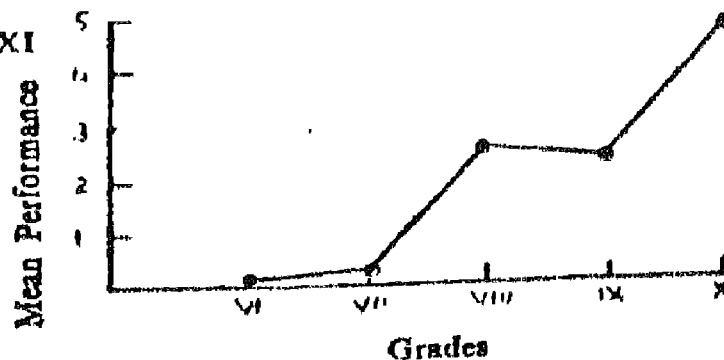
Hump in the mastery of thought processes on Problem No. 11

Fig. No. X



Hump in the mastery of thought processes on Problem No. 12

Fig. No. XI



Hump in the mastery of thought processes on Problem No. 14



Sandhu (1978) while using Valdy's as well as other problems with class as the unit of sample in the actual classroom situations in Delhi encountered the same phenomenon among adolescent pupils studying in grades VI through X. The descriptions of various dimensions of adolescent thought along with the mean performances, on problems used in this study, at different grades are given below :

Table III

S. No.	Dimension of Adolescent Thought	Mean Performances at Different Grades				
		VI	VII	VIII	IX	X
1.	Hierarchical Classification	.60	14.60	24.20	19.66	32.00
2.	The Concept of Ratio	.13	.00	.53	.40	1.43
3.	Information Processing	2.20	3.40	5.40	4.33	7.68
4.	Formulation of Problematic Situations	9.33	11.46	10.06	16.20	16.31
5.	Hypotheses Testing	.06	.13	.60	.00	.87

Consider now the graphical illustrations reflecting the hypothesized phenomenon as shown by mean scores on the above dimensions of adolescent thought as well.

Fig XII

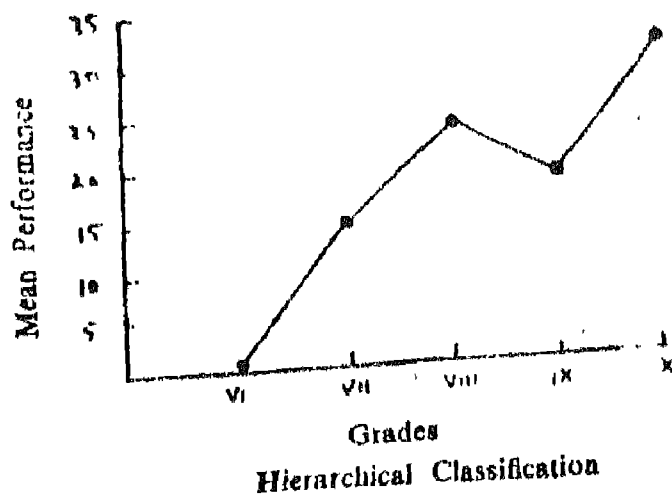




Fig. XIII

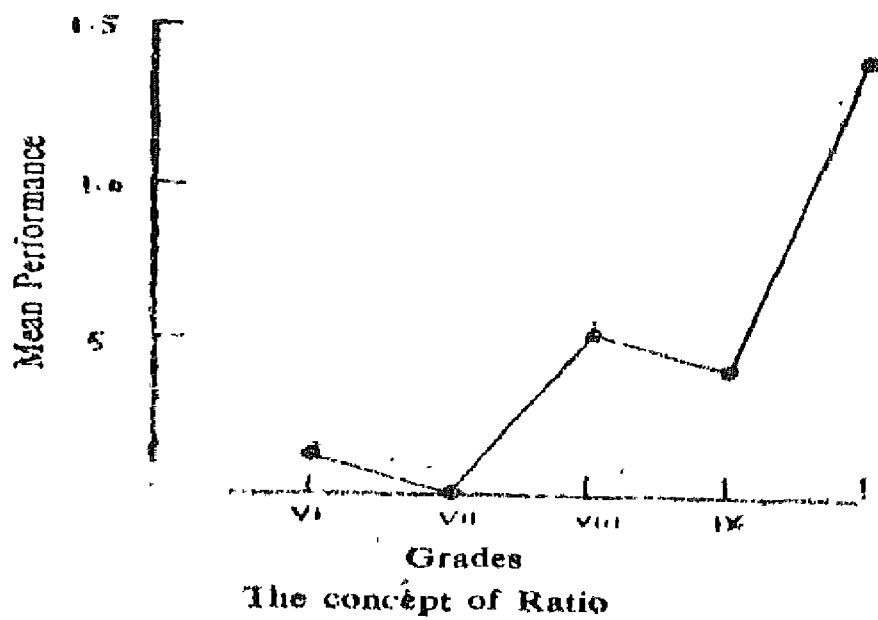
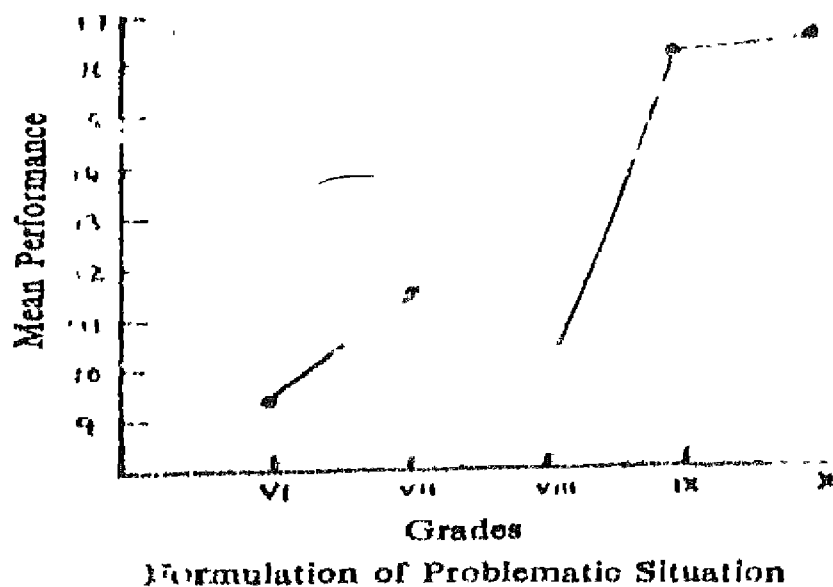


Fig. XIV





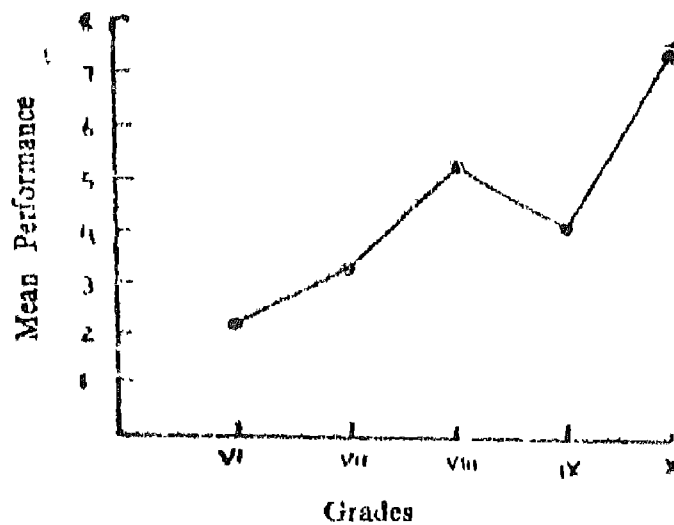
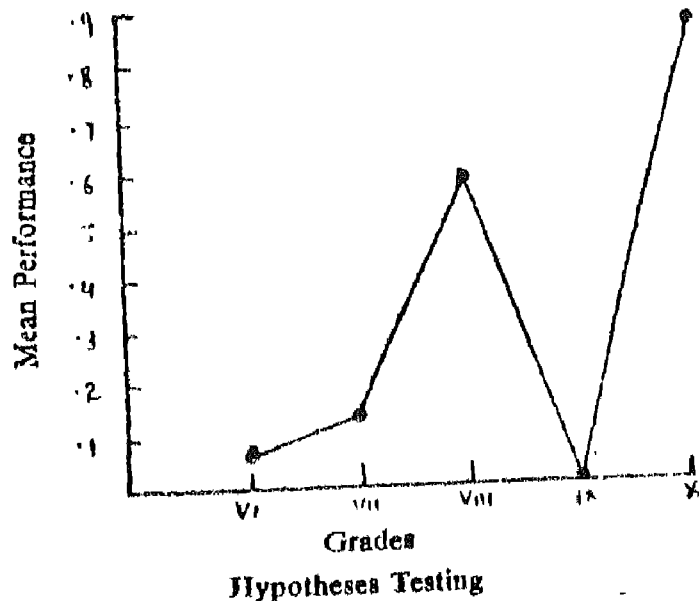


Fig. No. XVI

#### Information Processing



#### Hypotheses Testing

#### Additional Support from Literature

Due to the paucity of global literature in education and psychology in a provincial town like Ajmer, it is not possible to document this phenomenon if encountered earlier by other workers. It appears that Piaget and Inhelder, (1977), Lovell and Ogilvie, (1977) and David Elkind (1977) did encounter this phenomenon but missed





referring to it in their studies. Their data taken from *The Essential Piaget* when seen in the context of the hypothesized phenomenon indicated the same.

Table IV

Percentage success in Tests on the Conservation of Substance, Weight and Volume.

(According to Piaget and Inhelder)

Age	5	6	7	8	9	10	11
Substance (Transitional)	0	16	4	4	4	—	—
Weight (Transitional)	0	4	0	8	12	8	4
Volume (Transitional)	0	0	0	28	12	20	4

Table V

Percentage Success in Tests on the Conservation of Substance (N=322) and Weight (N=364)

(According to Lovell & Ogilvie)

Tests	Substance (Transitional)	Weight (Transitional)
Class I Age 7-8	23	5
Class II Age 8-9	12	36
Class III Age 9-10	15	20
Class IV Age 10-11	9	13

Table VI

Percentage success in tests on Conservation of Substance, Weight and Volume at different age levels (N = 25)

(According to David Elkind)

Age	5	6	7	8	9	10	11
Substance (Conservation)	19	51	70	72	86	94	92
Weight (Conservation)	21	52	51	44	73	89	78
Volume (Conservation)	0	4	0	4	4	19	25

Before considering the graphical illustrations based upon the above mentioned data, it is of interest to mention, that their subjects were, comparatively speaking, at the lower stages of mental development, namely, pre-operational and concrete operational as defined by Piaget. Secondly, special attention has been paid to the frequencies against the transitory stage of solution on concepts of conservation of substance, weight and volume.

Now consider the graphical illustrations of the data described above.



Fig No. XVII

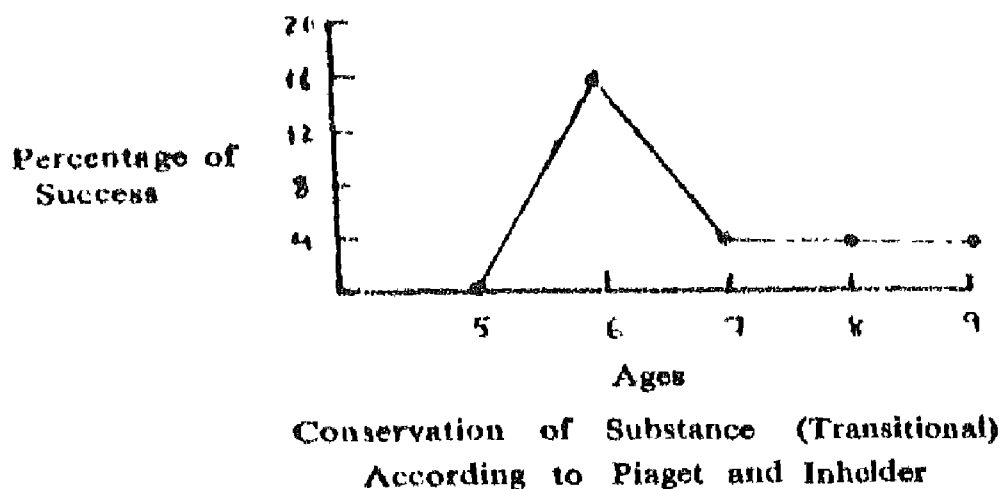


Fig. XVIII

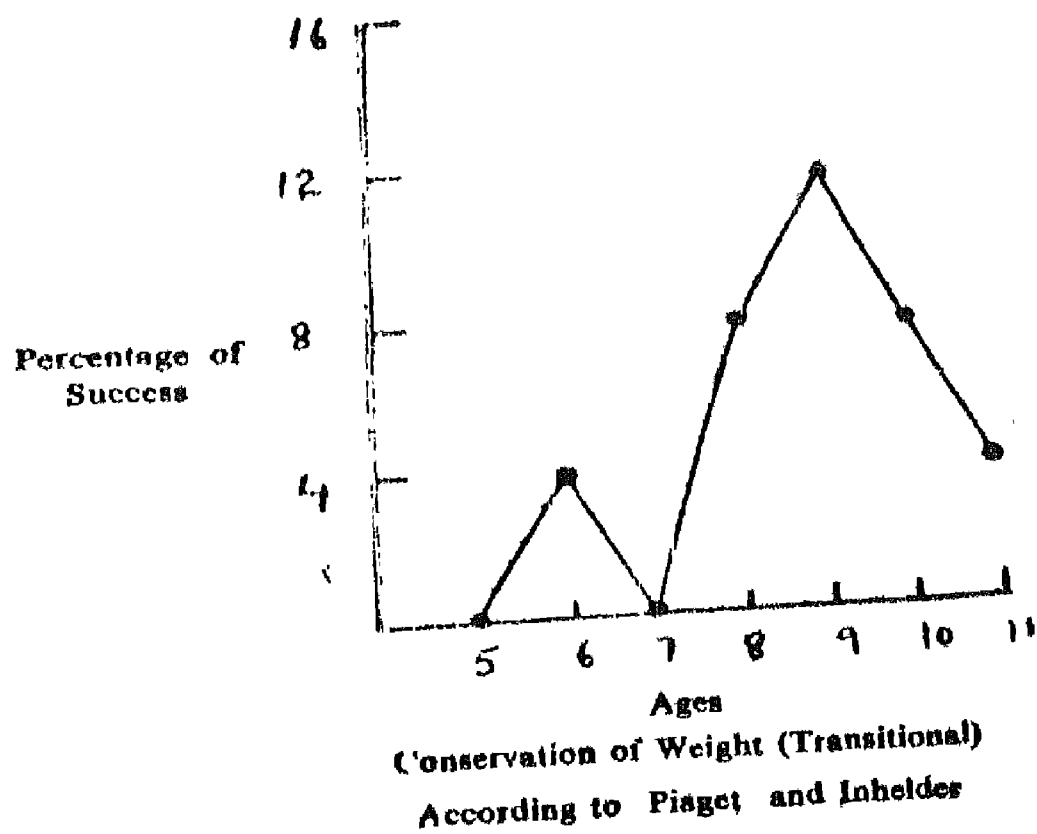
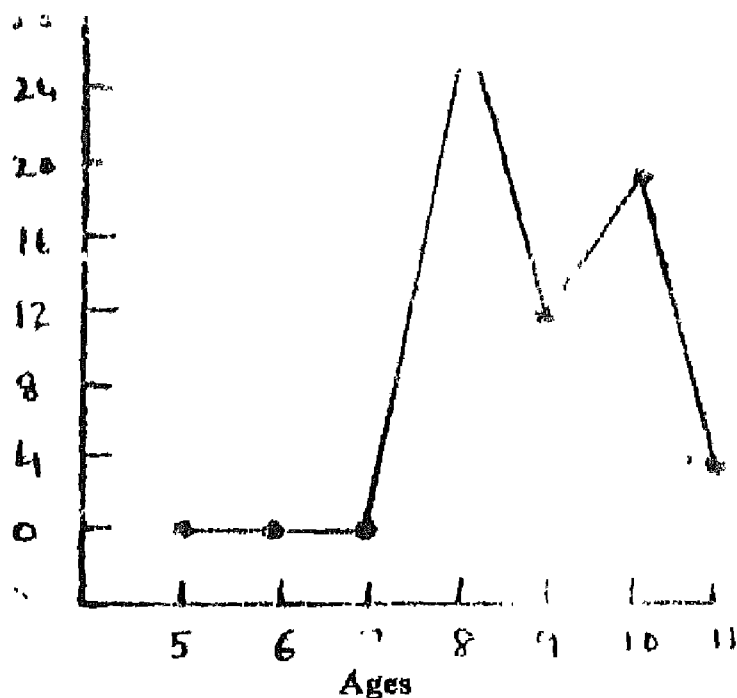




Fig.

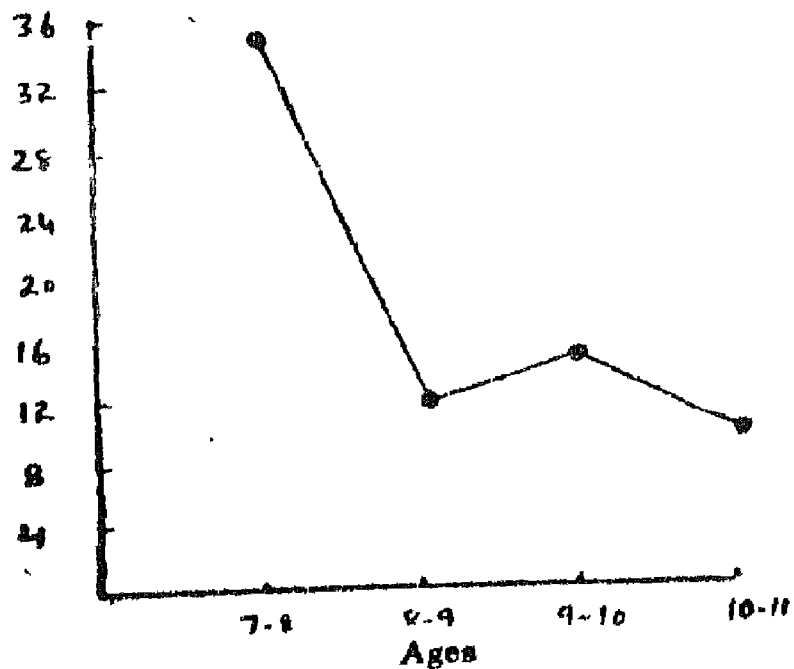
Percentag of  
Success



Conservation of Volume (Transitional)  
According to Piaget and Inhelder

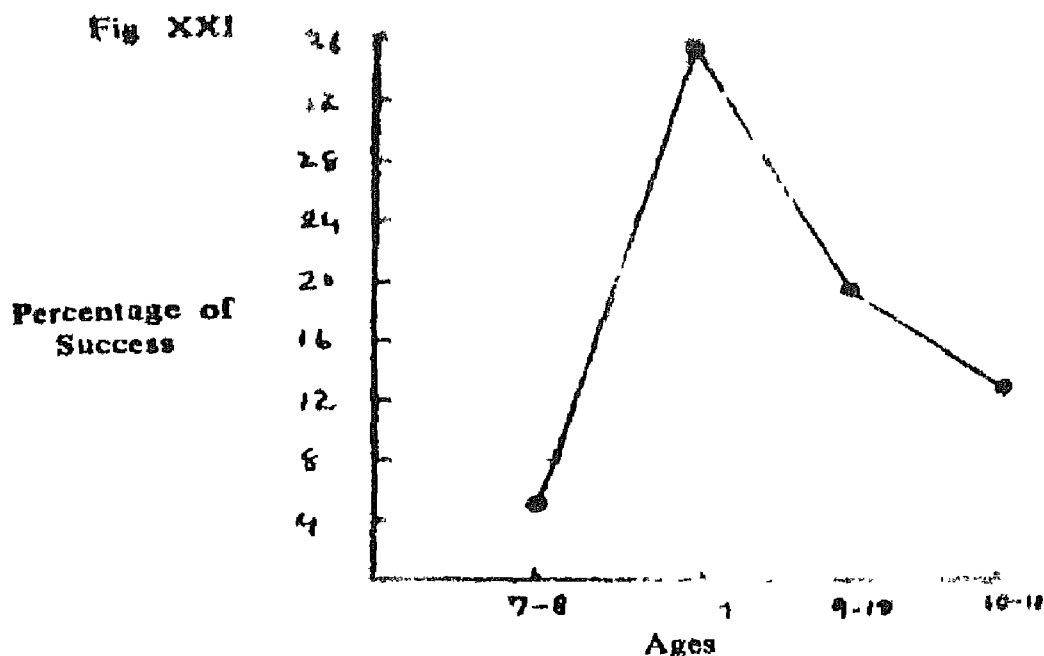
Fig. XX

Percentage of  
Success

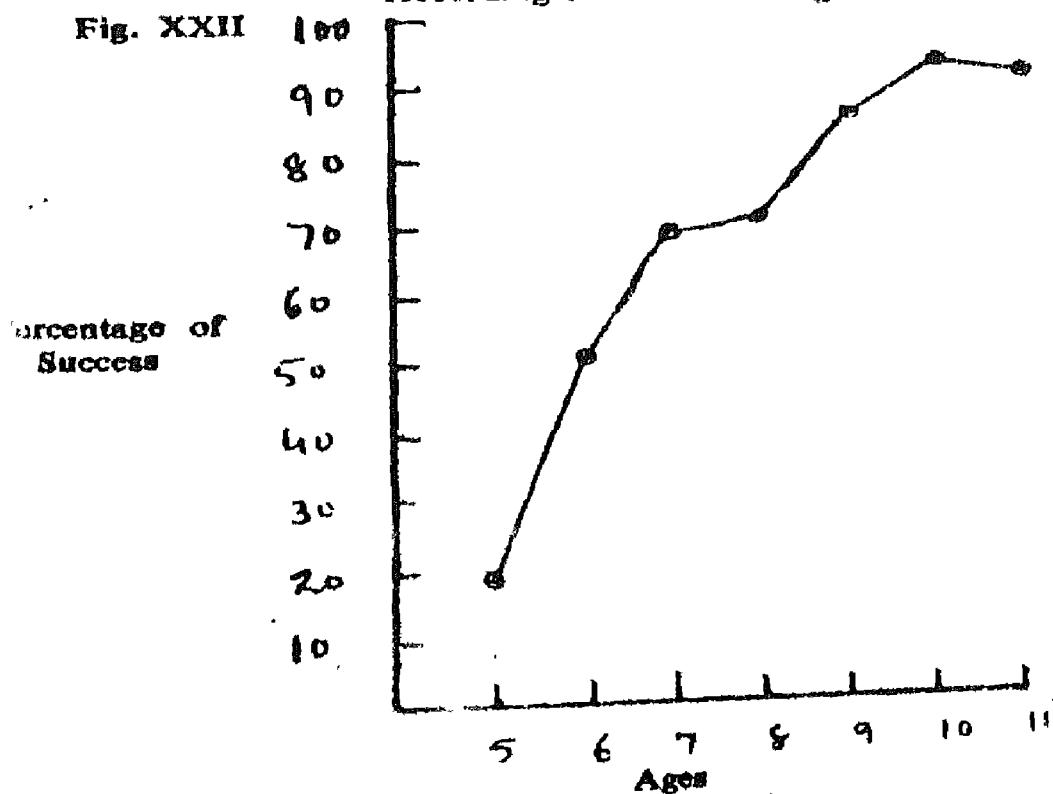


Conservation of Substance (Transitional)  
According to Lovell and Ogilvie





Conservation of Weight (Transitional)  
According to Lovell and Ogilvie

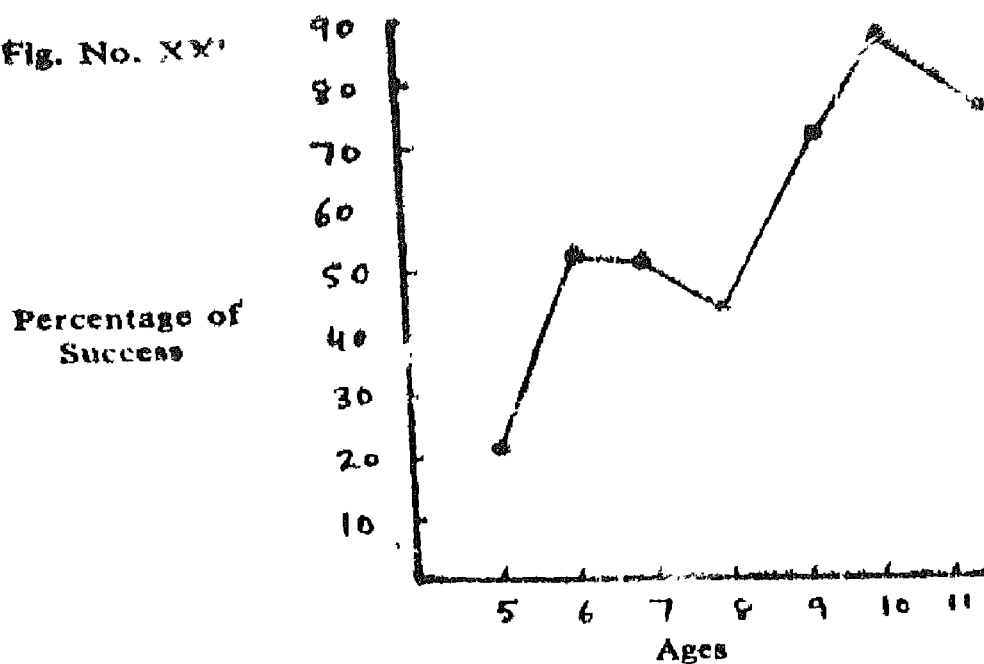


Conservation of Substance  
According to David Elkind



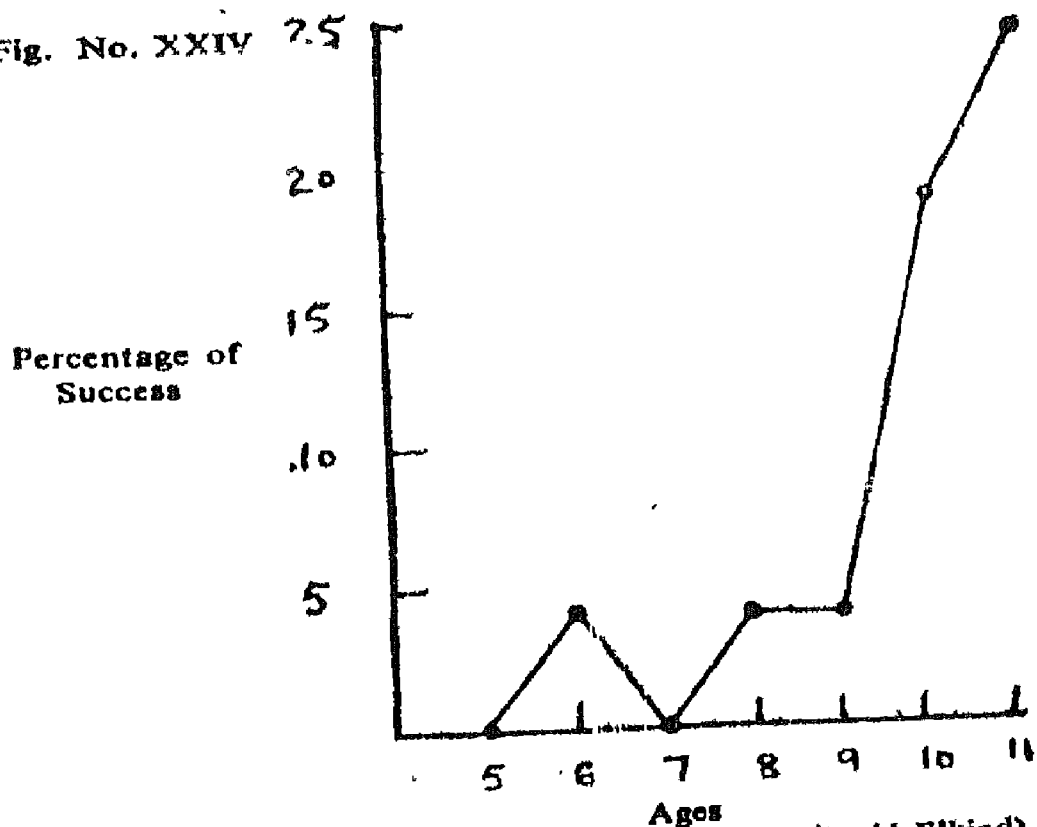


Fig. No. XXV



Conservation of Weight (According to David Elkind)

Fig. No. XXIV



Conservation of Volume (According to David Elkind)



Martorano (1977) also encountered this phenomenon on the performance at some Piagetian tasks in her doctoral study 'Developmental Analysis of Performance on Piaget's Formal Operations Tasks' though she could not detect it. The data reproduced from her study regarding the performance at some of the tasks are presented below.

Table VII  
Mean Score on Piagetian Tasks at Different Grade Levels (M. R.)  
(According to Martorano)

Tasks	Grades			
	6	8	10	12
Rods	2.75	2.95	3.75	3.70
Balance	2.75	2.65	3.40	3.35

The graphical illustrations of the above data are given below.

Fig. No. XXV

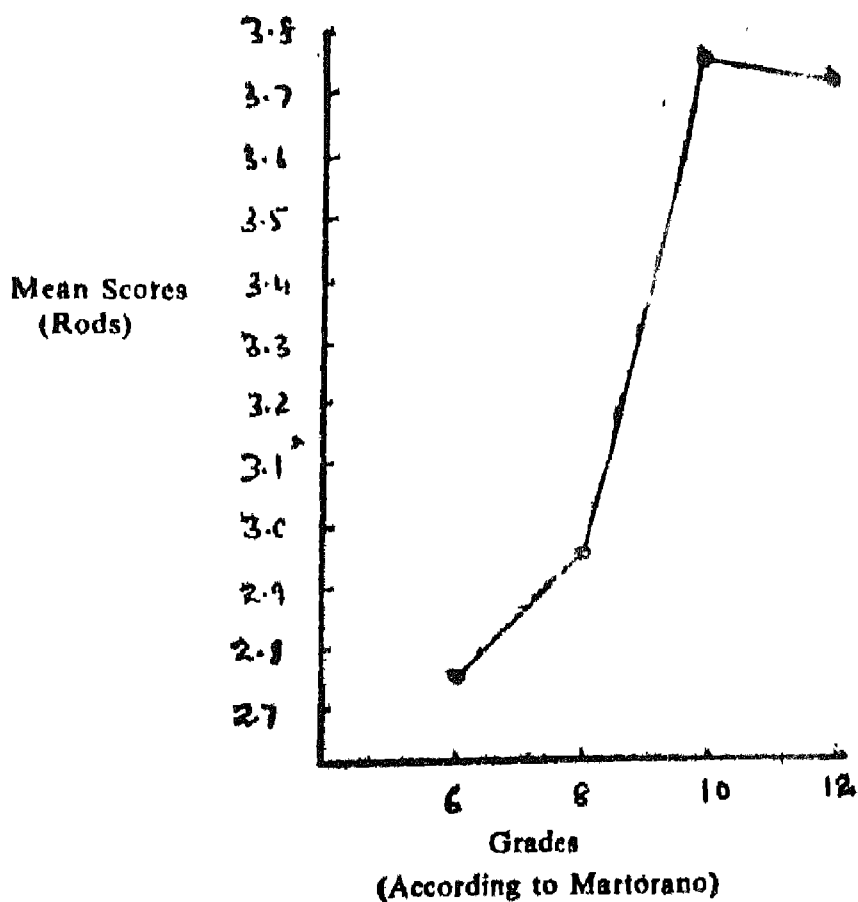
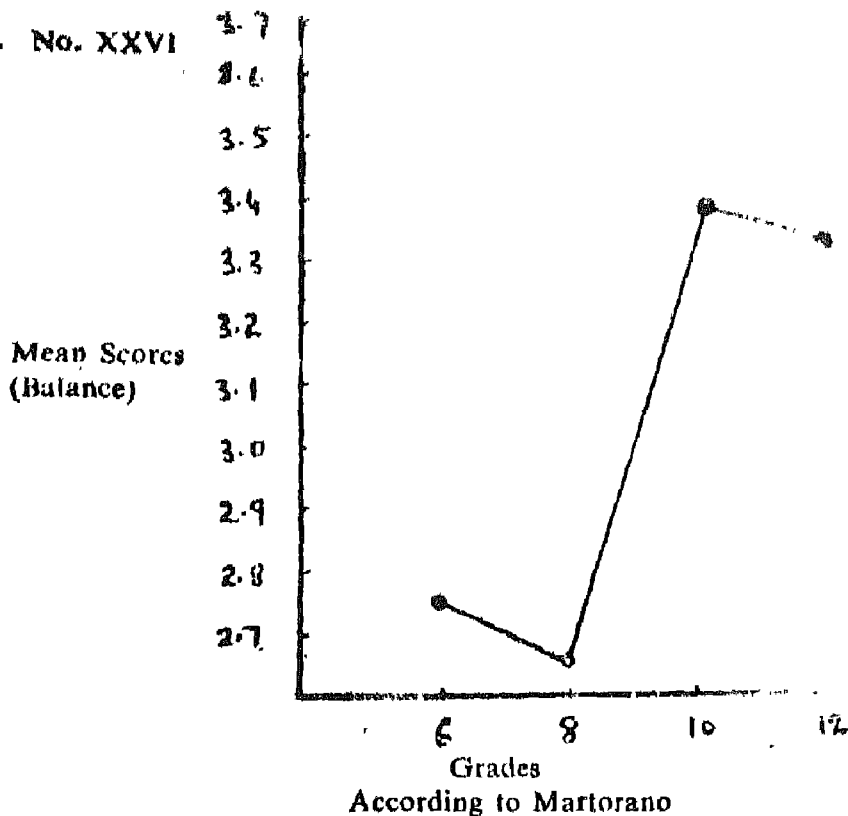




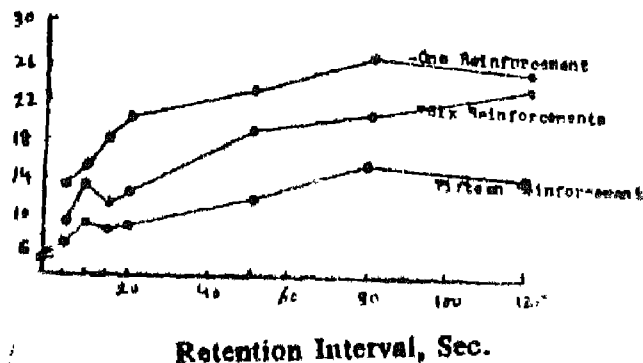
Fig. No. XXVI



It was a firm belief among motor psychologists that motor learning resists forgetting. Recent evidence suggests that part of this generalization has become suspect. It was seen that in short term verbal retention forgetting could occur in a matter of seconds. Adams and Dijkstra (1966) found the same in respect of motor responses : Forgetting is signified by an increase in error and it can be rapid, particularly, when the number of reinforcements is small.

The graphical illustration of the phenomenon is given below.

Fig. No. XXVII



From J. A. Adams and S. Dijkstra (1966) "Short-term Memory for Motor Responses"

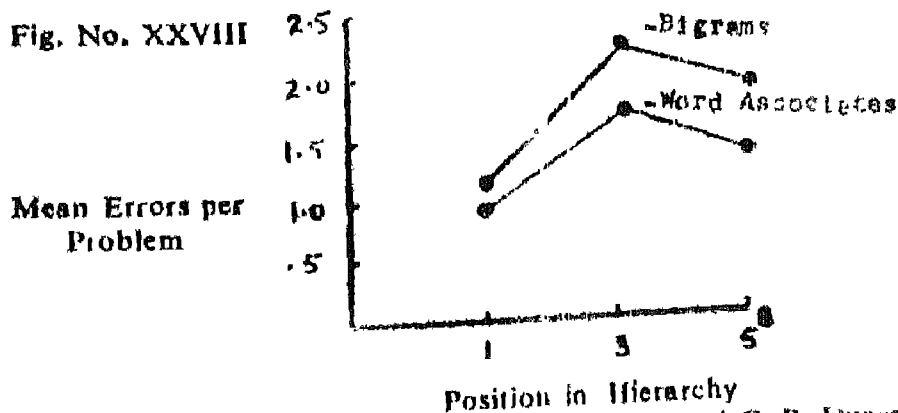


It is of sheer interest to note that mean errors per problem, as a function of problem solution in the response hierarchy, also appears to suffer 'hump'. In the context of Words Frequency Effects, Underwood L. Schulz (1960) has suggested a *Spew Hypothesis*, testable in a number of situations, that order of emission of verbal responses is directly related to their frequencies of occurrence. In problem solving, this hypothesis predicts that high frequency of correct response is inversely proportional to the difficulty of the problem. In the context of 'hump effect' it is not unreasonable to reword it as follows : with age as well as low score on individual problems or processes underlying them or both and even the latter three starting from zero as the ascending variables, the frequency of correct score is neither directly nor indirectly related to the problem difficulty, strictly speaking, in the linearity context. While maintaining the increasing positive trend of understanding with age, low correct frequency of correct score at lower ages appears among pupils on problems inhering continuous chain of reasoning which suffers characteristic ups and downs very very similar to humps of camels as judged by their remarkable increase in errors coupled with equally remarkable decrease in errors at higher ages until the correct response firmly settles in individual minds bursting through errors in cross-sectional contexts, with striking drop in frequency of errors, possibly on the development of reversibility in abundance within the context of individual problems or processes.

Two graphical illustrations taken from research literature and given below possibly strengthen a part of the hypothesized phenomenon in entirely different contexts.

Bigram from R. L. Dominowski "Problem Difficulty as a Function of Relative Frequency of Correct Responses"

Word Associates from C. P. Duncan "Response Hierarchies in Problem Solving."







perhaps the same sort of support is received when the hypothesized phenomenon also appears in Serial Rote Learning in the form of a 'bow' when frequencies of errors were plotted for a group of subjects engaged in learning each item in the serial position affect. (Krawiec, 1974) Lastly, Prof. J. S. Bruner when contacted had this to say:

'The type of error that you refer to, which we speak of as growth error, is one in which the growing child tries out a new strategy although it is not well developed and uses it in place of an older one which has been working well. It is errors of this sort which suggest to me the venturesomeness of learning during this early period, the human beings are willing to shift to a less certain and more powerful strategy, before they have it under control, in preference to one which is safe, sound and dull'.

### **Concluding Statement**

On reflection, one is led to conclude that this phenomenon may appear clearly if attacked specifically. In our study, it was not the specific object of investigation. Taking an analogy from optics, polarization of thought during its disappearance is also suspected by authors to suffer from hump. At this stage, no firm explanation is possible because the past history of individual subjects in respect of concepts under study is hardly known for all practical purposes. However, it is possible to suggest the following additional hypotheses for research :

1. Hump Effect appears when thought process moves from a lower stage to a higher stage, the most fruitful area for attack being the transitory period between any pair of the two succeeding stages.
2. It appears at all ages, choice of problems being the determining factor, among pupils at different levels of intellectual development when new concepts are under development. It may appear in sex difference studies relating in achievement and intellectual deterioration among adults later on
3. It is suspected that it may equally appear in the above mentioned contexts when :

( i ) Longitudinal studies on thought processes are undertaken.



- Beard, R. M. An Investigation on Concept Formation Among Infant School Children, *Ph. D. Thesis*, Institute of Education, London, 1957.
- Bruner, J. S. et al. A Study of Thinking. *Science Education*, Inc., New York, 1962.
- Bruner, J. S. Personal Communication, 1976.
- Burrack, Benjamin. Methodological Aspects of Problem Solving *Progressive Education*, 1953 Vol. 30 pp. 134-138.
- Busell, G. T. *Patterns of Thinking in Solving Problems*. University of California Press, Berkeley, 1956
- Burt, A. S. The Differentiation of Reasoning Abilities at Adolescence. *Ph. D. Thesis*, Institute of Education, London, 1957
- Carpenter, Horton and Atkin. Quoted from M. W. Travers. *Essentials of Learning*. MacMillan Company Inc, New York, 1963
- Deutsche, J. M. The Development of Children's Concepts of Casual Relations, in R. G. Barker (Ed). *Child Behaviour and Development*. McGraw Hill Book Company Inc, New York, 1943
- Dominowski, R. L. Problem Solving In *Fundamentals and Application of Learning* Ibid,
- Duncan, C. P. Response Hierarchies in Problem Solving. In *Fundamentals and Application of Learning* Ibid, 1967.
- Dunker, Karl. On Problem Solving. *Psychological Monograph*, 1945 Vol. 58 No. 5.
- Durkin, H. E. Trial and Error, Gradual Analysis and Sudden Reorganisation : An Experimental Study of Problem Solving *Arch Psychology*. N. Y. 1937 Vol. 30.
- Elkind, David. Children's Discovery of Conservation. In *The Essential Piaget*. Edited by Gruber and Voneche, Routledge and Kegan Paul Ltd., London, 1977.
- Gruber, Howard, E & Voneche, J. Jacques. *The Essential Piaget*, Routledge and Kegan Paul Ltd., London, 1977.
- Guilford, J. P. *Fundamental Statistics in Psychology and Education*. McGraw Hill Co, New York, 1956.
- Hazlitt, V. Children's Thinking. *British Journal of Psychology*, 1930 Vol. 87 pp. 447-531.



- Heidbreder, B. Problem Solving in Children and Adults. *Journal of Genetic Psychology*, 1928 Vol. 35.
- Hull, Siroke, Haufmann and Kassarin. Quoted from the abridged account given in the *Selected Readings on the Learning Process* by Theodore L. Harris and Wilson E. Schwahn. Oxford University Press, New York, 1961.
- Inhelder, B. On Problem Solving in Paul Henry Mussen (Ed). *Hand book of Research Methods in Child Development*. John Wiley and Sons Inc. 1960 pp. 421-455.
- Krawiec, T. S. The Psychologist. Oxford University Press, London, 1974 p. 215.
- Kruglak, H. Some Behavioural Objectives of Laboratory Instruction. *American Journal of Physics*, 1951.
- Lovell, K. & Ogilvie E. Conservation of Substance : Growth of Conservation of Volume. *In The Essential Piaget* Ibid.
- Maier, Norman R. F. Reasoning in Humans. *Journal of Comparative Psychology*, 1930 pp. 115-143. vol. 10.
- Martorano, Suzanne, C. Developmental Analysis of Performance on Piaget's Formal Operation Tasks, 1977
- Marx, M. H. & Bunch, M. E. *Fundamentals and Applications of Learning*. Mac Millan Publishing Co. Inc , New York 1977 pp. 249 and 397.
- Mealings, R. J. Some Aspects of Problem Solving in Science *M. A. Thesis*. University of Birmingham, 1961.
- Mumford, S. C. Factors Involved in Problem Solving with Special Reference to the Problem of Insight. *Ph. D. Thesis*, University of London, 1937
- Muthulingam. An Investigation of Certain Factors in the Physical Science Courses of Secondary Schools in Relation to Aspects of the Achievement, Attitudes and Interests of Fifth Year Pupils. *M. A. Thesis*, Institute of Education, London, 1963.
- Neal, L. A. *D. Ed. Thesis* reported in Science Education, October 1961. pp. 313-320.
- Oakes, M. E. Children's Explanation of Natural Phenomenon, *Teachers and College Contributions to Education*, 1947 No. 926.
- Peel, E. A. Psychology and the Teaching of Science *British Journal of Educational Psychology*, November, 1965.



- Piaget, J. and Inhelder, B. Conservation of Substance, Weight and Volume. In *The Essential Piaget* Ibid.
- Sandhu, T. S. A. Factorial Study of Adolescent Thought Using Piaget Type Tasks. *Ph. D. Study Under Investigation*, 1978.
- Stendler, C. B. Cognitive Development in children and Readings for High School Physics. *The American Journal of Physics*, December, 1961.
- Szekely, L. Knowledge and Thinking and Productive Processes in Learning and Thinking *Acta Psychology*, 1950 Vol. 7 pp 338-407 and 1 to 24
- Vaidya, N. A study of Problem Solving in Science Among Certain Groups of Adolescent Pupils. *M. A. Thesis*, Institute of Education, London, 1964.
- Vaidya, N. *Problem Solving in Science*. S Chand and Company, N. Delhi, 1968.
- Vaidya, N. *Some Aspects of Piaget's Works and Science Teaching*. S Chand and Company, New Delhi, 1971.
- Vaidya, N. *A Study of Some Aspects of Thinking Among Science Students of Adolescent Age*, Ph.D. Thesis, University of Rajasthan, 1974.
- Vaidya, N. and Rajput, J. S. *Reshaping our School Science Education*. Oxford I B.H. Publishing Co., New Delhi, 1977.
- Vaidya, N. *The Growth of Logical Thinking in Science During Adolescence*. Oxford IBH Publishing Co., New Delhi, 1979.
- Welch, W. W. Review of Research 1968-69 in Secondary Level Science *Journal of Research in Science Teaching*, 1972 Vol. 9 pp. 97-122.
- Wheeler, D. Studies in the Development of Reasoning in School Children. *British Journal of Statistical Psychology*, 1958 Vol. XI, Part II, pp. 137-159.
- Whellock, R. B. An Inquiry into How Far Scientific Method is Gained from Scientific Education. *M. A. Thesis*, Institute of Education, London, 1953





# ANALYSIS (V1)

Original data regarding the different Variables

Variables are to be read as follows:

Variable No.	Code	Format	Columns
1.	AGE	F2, 0	7- 8
2.	SEX	F1, 0	9- 9
3.	IV	F2, 0	10-11
4.	TRF	F2, 0	12-13
5.	AMT	F2, 0	14-15
6.	A	F2, 0	16-17
7.	B	F1, 0	18-18
8.	I	F2, 0	19-20
9.	D	F2, 0	21-22
10.	E	F2, 0	23-24
11.	F	F2, 0	25-26
12.	G	F2, 0	27-28
13.	H	F2, 0	29-30
14.	I	F2, 0	31-32
15.	J	F2, 0	33-34
16.	K	F2, 0	35-36
17.	Q2	F2, 0	37-38
18.	Q3	F2, 0	39-40
19.	Q4	F2, 0	41-42
20.	Q1	F2, 0	43-44
21.	RA	F2, 0	45-46
22.	CL	F2, 0	47-48
23.	OUT	F1, 0	49-49
24.	GAA	F2, 0	50-51
25.	P13	F2, 0	52-53
26.	RAV	F1, 0	54-54
27.	FPQ	F2, 0	55-56
28.	ICI	F1, 0	57-57
29.	STH	F1, 0	58-58
30.	CV	F2, 0	59-60
31.	QRP	F1, 0	61-61
32.	QW	F2, 0	62-63
33.	AA3	F2, 0	64-65
34.	AA4	F2, 0	66-67
35.	AA2	F2, 0	68-69
36.	AA1	F2, 0	70-71



1	11118266221320803080711071007070812084313452200010671064524749446532102101
2	1111911261131060309090905120805070923102701304008210115651394560213104201
3	41106092000931006080911107111006090627092601203001210826342435260422106202
4	111192023123030408060608060610040808082510500309006201026341444062214102303
5	4110711200231008080808100412060810082007030000001001305143465252313108221
6	4110609161240811060609111308091013111306150030000200405130494052113106221
7	11108142808607080710100805081206090937160000000005201604342493052113107221
8	41110122104110100905041206121008080719112700000000200713440494546417107211
9	111141515134080606061410041210212063512260400003004051463147454412103303
10	41114161510410081010080804081014101012100010600000200204745465152518105202
11	11123232810205080710101107041204040629115420500003301016047426266424105303
12	4111010211431202081008101208080808122714362200002008060484058416105102
13	1110814280430404010309006020303040422102701300001000903435313442212108304
14	4111702008508110908110905110503020616112711000011010816171535046422105202
15	1111412280720709100709021007040810101810090070003210615063565258216104211
16	41110162000507090509110012071109061022132500100009100916357504756316106211
17	111121233062080412141008060606060462410000400000001005250595158127104211
18	4111410211431204080610081412100608102213270070100610050585058555247103101
19	1111313150850409051207110909012110825090600100002000204548433150214100312
20	4110912161400607100508050604100312122050000501008010703471456250123103211
21	1110607130631109041006121009070908061011260000005200736353524751473703112
22	4111411170841104081011130806090806091404260010005000624956555034117107211
23	1110913170950507080812070409090608071517432000008100726886615460113104121
24	411091923112100505101101508101108101412273000010820042606150571113104121
25	11108141811208060812100808060406100703100900103008010604450645847216105111
26	4111210181021007080611060610120807082208270004006201325350467148312104201
27	11120121306110070712080711070810050931105403020082112440444444112108302
28	41107201006509080911100808101207090825095400501002010725635543453113104131
29	41104091811210090607120604041007060528060011504009120914958716651112103101
30	11104080807108081010070606060708102508272070100010101473558505010102301
31	4111900200531006071109081109081007081324095311600106020604862515252324104101
32	11108112410203070906090711060712080716082310301107030016362575052112103302
33	411121318113080605120606131207091010240927000010043303030355474028112103104
34	1111816170410909070507090505080310071908261070000622040434743485247104101
35	4110518170630410100904031205020608062608270020210712040565505460113104121
36	1111200240840808091010100407080707113111270901000320205455526165112105101



37 4111513160321105121110806100613081121102500601005020614359625870414106301  
38 411181118005070808101070808090901021120000200003420115350486150418103201  
39 411191319062060508140908060906071030095010100220101449675245312104204  
40 411171110072006070711040806080909081706270010010000704736515330113108321  
41 4111216121420510060908050909101004102611291080010000606057554050113106121  
42 411180820061070908060608071010081111341054050000100205153444130212106211  
43 41116131506305111108090508060509082210302030000100503842334142213105102  
44 411210819113100506080807081011080810231100101000001005041424140422103102  
45 41119131910310040508050808101010081910272210000000705867465667113109102  
46 4111621221340809080507100710060610074033545130000101207053604050112107304  
47 4111509260020412091010120505080406092407241000000100403057384130422104201  
48 41114132608212120912080506080810081020162740504107230905348534052122103201  
49 4112021260930608100906110903080709082616151000000001716346334750112103102  
50 41115172500208101208121005101404060718132700501100300804950553040213107311  
51 41112020740307081010120607120809062714360030000200714250444148324104301  
52 4111109080030613071111005080507091221100206000000010333342363312106101  
53 41106101608406071208040408041008060814072621300003005057645554400103121  
54 41112191602100612090911080604080911140909010000010120445551465144105111  
55 4111710280950808101207110712070810240809108000010014744535661122104204  
56 4110803061220808090710120908070708491002070000000040524742444822105304  
57 41108121611403080006110810080804090921005000000100203339424140312103211  
58 411121309103120804080810080609081009120709200000000020505455250416104204  
59 4110815190821211012080405080806070420092221500303201004646534030326102102  
60 4111113181030310121309080611090706122311270150300500605036494030434104101  
61 41107132408406090908080705051003070716112710701008101125140434140312103104  
62 41110222309407090710080808100806080924084631613107500606441464241222104203  
63 41113102010306060812140806070808101015101730200110200725831365747412105302  
64 41119131706209100808080408090403090716134241601105710505854695060446103201  
65 411091307060050604070406060505060604170627202000040000343314241112103101  
66 41109071610407100611101009110506070922070001500000100505248464050117104211  
67 4110613181061005081006060907060406091410030200000100504744524630112107311  
68 41117103606506070608081110061006080920080501700101100505261504547412105202  
69 41108113208312120608101014080804061221090920700000101215753624848323103221  
70 4110808190631006040708060906110810082206260070000000513438364050117706211  
71 41110051911308091005060909080605030729122220501000400426744565050112109101  
72 41116112610403110911000307071109070935082710100000100205731435550113106111



73	1111111170331109080705070907090605093330409101000000002052525565648312106202
74	111081027125070211100800081211070912191000000000001104738363741322105201
75	11108122611511081112111102090410070929052700300001001574856504112107201
76	11206111507007060701040602060406321115000000101011515153503511210301
77	1120612270421208020806080608040800042412080000000000815858625642243106111
78	1120710221031011091210060504060610103208270010001000916767675667524103013
79	1120400181440908130909121109060807062809030000000110514749424645312105104
80	1121700211020404060606040604010404281316000000000071355545404721210304
81	1121414170841010121508040608080809061910420100300020150538434414143410504
82	11208091208608041009120006061010111200910009000010061355137425424105104
83	11208123110506051108080805041204040621112704002020050464054425434102101
84	112070615063030612081206100812100610241026020000100115151433050122103101
85	11206082210200909080811091007071008180734030000110812956715160112108201
86	11219242306202060410080608100402040225134131900007611126661576241512103102
87	11217211807411090612131007090507070935064802000008100827158637161511105202
88	112061224085080908111110710100811103307293110000100324947436142322104102
89	11229182708310120611121107090805160431152722204008610245958496641322104104
90	11221162208207050808090810110905081023045100703006100706166495031416106202
91	11215142712312060410121010106081062912380100005110455451545851414105302
92	112140927110051006060810004020702081810320300106000914945433641444106311
93	1120909181030609100508061306090506091411000000000001048524042212104301
94	1121611231210408100608100812100806081309140000000000303463534151214104121
95	1121613160820011030710070507090814073015210080000110404850544052424107211
96	1110914160750611071409050808090911120092800003000020444049474112111204
97	1111814201240812101010040406060407111408390020000011040485460425114102301
98	11108151909410081014100310021114080717102701800009102424751435238416105101
99	111181116062007090908100010110510132109311060110509102258666545418107301
100	111101320085081409070808080613091208181138703001061007255665256122106103
101	111171414103070507060609100912051105280848000100021054444357551122103301
102	11117172910507120910151307051007040808104510503200100623545432071312105102
103	111151815103040808080908120608100434135420001003101215152585035212105301
104	111110616122070807110706081008060707230924000000001435162516258112108203
105	11113082610411205121110612061214070514543090001210626245496762422102101
106	1111612210331009040507080904041207061809300010000010003520524238422106202
107	11110092010212030606090810081004050620072703000000210614134553741412104201
108	1122719191651512141509161509140915111800000000101200304556515035112107201





109	41113131810105111008090908091112130618100910500001000303420474838412104201
110	112030815103060208081012060804040604250814011010002006145505550414101103
111	4121517191040614061212080812121210043620532050000401107154616250112106302
112	1120513240610404040804020402020404220800000001100605554665741312107201
113	41214162212004100410121206090608100616083630302003001316650717171112105203
114	11208122408306060610120808100602080223415454130000630071585061566222106203
115	4120516271250806041004080610060407063109410120000110081546658383122107203
116	1120212201041010041006060608060210063704000000001100105650495058424104101
117	4120811110406050309080403050404080217090000100000020304755523840414106311
118	11205081207211020709110612081208051024041800000000200304658566147312104101
119	4120615130810406021010202040404060227111840300002100606652666762494103102
120	1121410250820710100308101010060407102111000010000002060405249438112106204
121	4122112221471303061014120808070508032511230010000000207143615048112106204
122	1120914290620809081014060809081010101610090130200400515355636167316103111
123	41214172710108120810060406080806140615082600100000100304248495762116106121
124	11211141803407101006081004070509090721102430200006000515866717171122104101
125	412150722108309070908071208070508100832110601100002000125142436353113105111
126	11203161608300909071204111109080822080000100000006005146384550112105301
127	4120815160841108101008060512100612061407000000007201005250585062112106303
128	112120260210302010001000010002010119084220100001100614748474037426106202
129	4120515230020806020709080610060804102806250000004110915355415045424106122
130	11209062109209080610100303080806081017090000600000200304241384241424103201
131	112111322043070810060910050709070709140404070330600030554655350424104204
132	11207051510312101013101006090508090816041400202002100203435424530422103101
133	4121115180620508100807080710090810122314001000100220204843384145112104101
134	41209131008307091213100811080805080723062701001100620404843534747112105101
135	412070625082050808060403120812081410200508000000420515944304747432104301
136	41212102908210090613140808110608110637072700301000120416240440448436104204
137	4121213130020507091308060408120607092609007110410361031304655052422106301
138	1121313240830708050913070809060910092511002050000120217048554041544103102
139	41210101311411108090908080905061020074500400100130504355564558112104202
140	1120809241030508090807110808060807062308030000100220304303530412103224
141	41212192202107080807080804060602101809061120000220505135413835486105103
142	41212114074091108071207071110607091911331100100132040565560762114109211
143	4120913290830904060406041206060806102110271100010200514767425063217104212
144	41213142811104070706090608061203110633164321200100130206450476450122104201



145 112161025023031207101211081404080804261345209001030000215232605070314100312  
146 1121813240830612051011100812081008043515302100010040050554258545416105211  
147 1121607240630061004041006061207040931092700800000003036304870502100302  
148 11215132209300708101208030806081038060041200000020141414615641122105302  
149 11212100811400081109000800080906081028070000000000003037533030214104201  
150 1121507030220308071008081011050908101006001002000000004048504730344102301  
151 112151316100710080812080507070809091804003040000200704550426060426105301  
152 1121108050830406101010001204120408123207030100000000303650576260424104112  
153 11210808050440512060607020209040502040608041040000000004151695060412102101  
154 11202092309314040611080906101213091126100304000000200815651614057322105304  
155 112220302082081104061104061207090305091709001070000000106056485040417104112  
156 1121002100100903050812081006070810320810500000000203351424050312104201  
157 11215221502107080813080808100808081028075441401006230305850504050436104202  
158 1121208181220603080411090704060711082809182020000003004947395151314103101  
159 11207152506208070810070007060905080608070000700000101205842464450212104101  
160 11206110411200090307100910100605091420040010504002100604159555652112105101  
161 11213122143510110809100507120716110803102500002000400315457595060324104101  
162 1121111131230616040914070807080810081609273130000200825384616150323108211  
163 11225171807112060712081209040412070512075441400012740206080646460412104201  
164 1121005241001208071007120908121009101406062160000000714753443044424104101  
165 11218172411231108090808110605070705092504202040000310051448151606434102101  
166 112131017083070805090809080809072408264060000100203451525050112104203  
167 112111621103101307091011120509100811090414104000210011476343533312105312  
168 11215171411312060412151009080705060817052741100002000404763616172112107304

169 121081928125060805140914060604000407351154019000032008153303346441414102101  
170 121181018101080906120810080412121008210909206000034207042250414050216104102  
171 12117221807608060607110808071009050832135420801002101716241385237432104201  
172 12116092414308081006121608101006080621084510000030006136442404212103104  
173 121131521084110612060904120705030309161251014000200303648335232112106303  
174 12108081700505070609090703070609070630092401400002031115550475045432103101  
175 121232016022100706080608091206101062014541210100121090454454304212104201  
176 12116181410304080711080608080412101018115410900001300914552573052113506221  
177 12109092608411107060908005071008072409543150300922225661546055112105104  
178 121101823093040910611071007090510102011402001006120005054524440422104204  
179 121271423114061212100805140708100909220945218040063108155545052213105121



180 421151122093051409110050608090606032911273000206000613058333035324104201  
181 1212420240830609110908100411106060833105421308007840906061505758112107304  
182 42118222600411070710070309130811070925095431406006041244752574835424104102  
183 121211622103080808081008080408081709151180300401217050655455122105102  
184 421131118084080711108110407110809092510513090400720090450546250422104201  
185 12110201414300121308080907090905060625093221102008031225447444040114104202  
186 12113101912403041012110410110204120931054800202004000323540495040123106301  
187 121192219103121008081011106104060816114731200005301014948413542112106302  
188 4212208290830908051108051105091211072309062080210910031394339434424104112  
189 1212519201220806060605050311106101006092700201007110624245515451414106202  
190 1213024291251307041411307080708120837105421205006231536070475065313108301  
191 42112102207312051012121012070804060919093500201002130922514244437412110201  
192 421131212124111008100610607080907112408270110100070111505254445122105301  
193 121261313123040210081204080808060432155401204003600814450544254112106301  
194 4210816231421400010908080807120806072317540040000300827157504347112106321  
195 12118161706204030408100602080206040424135431802007031735854635748515104103  
196 42118111908510081010101200111006106180624306000220150494454485112107301  
197 1211111220830408100610080010202080023123941201004200203145344142426103201  
198 4212231300831003020712060404004060039133741006006731534852635248424105302  
199 12119241802207040606100404040200104221126210040021014438372941414103201  
200 12114151908408081008121204060804110833071601402001300503746444053412102101  
201 121061416163060806081204061012000404330847000000511031473440542112105102  
202 12116161806305071008080800050202100633113231501002201325138294037323106121  
203 121191624101100510101010060406021009226132501300002121125940596367414104112  
204 4210714270840705110907110709080808081911300090100400031485050524110200403  
205 1210813300307070805040811120809070621114531703609130836148615761412104303  
206 121082526083060410081010106021008082209303102011200416352585050203003321  
207 1211523230230910101010602120406040827075421104006701217162646058113107321  
208 4210523230520511080809050509060807102116010100400361170525546147312106301  
209 1211712281211206081012061208120812083313303130100031071485852452112101101  
210 4211112181450810121010121212060806062314261120200571100456348525216106102  
211 1211218280630911090508090508130709061808263090002510712920313031112106304  
212 1210710251220908121212121112131109164308003100001021191394047341424103104  
213 12104172810204080408080408040202060416113601600000100835865704753112106301  
214 42109221803110011208100702090907081029105405005003143556260624710707311  
215 4211118211010402040406020406040402102115274210200973112625062505113109321



216	12107101705210091011121008090611080620105110400008001035352454347112104201
217	121610180051011081313061309100511062011273010000510101584044140112106304
218	1210821240930808030708051106091012270854210010510123454641547116107211
219	1210808141030802100812080210040406023012361040220411125142565046444103202
220	1211109170730610080908120604060208102011253020100901013856475251212106301
221	1211312210720305040206010202010402011810271030020611093236384038312103201
222	1212217271410210071106060314040811103010540190300501100546463030112105102
223	121212026102060206091113060511008084614543120470732073585756607117103311
224	1211917311040005080708101110810110915104501501705221005846513041112104201
225	12108172514305110810090608100808080839084311300004220304304033031112108202
226	1212112241001404110110508071107090840183600703703220535682475652113107221
227	1211711271021009060508070710120908021209541040705420605250294842113104121
228	1212014191320703080711100609100705051710300040100023021455149441112107021
229	12126193308108060810081407120404090422105401008009120015052514041122105301
230	121191525003110906121011100712081010210827030050220404031404047113106321
231	121281526084040905100606110808080911201254000101600715669535450112106312
232	1210909200410509111070905080709091329125100500005200806451416461112103201
233	121191419115060907080907100807051036171452100100750040464650445122106301
234	12119142308311041009080707051210080918125421400093008161646660514102102
235	1212110221021105111210081008110804122110542220501200825458575851412106202
236	12118211812310040410141009061108080323074831401003501404946463737112106301
237	12108162102212020811090006081304061025122730200006201414136366140314106201
238	121061619111004080909090709120404092507122110100130070364046373113104211
239	12118132711500080410120211070807100519113630305000100225346564660114102211
240	12120202408310060508080606080606120928104650303009000815958395042112107203
241	12120211902211040603101212000806071426095441604008000915640664050432104101
242	12117132406400100710060400070812140916133931501000220614052384071416107201
243	1211618260840010060705070005070808091415141103000100214151384048112106101
244	12117091808203080606081000070706090916120010200103200513857433047316108121
245	1210617180210005080713110608040808031613094060000001407070627050428103303
246	12113211910120610110805070708100808131151210000021100574044504112103301
247	12117221502207090709130608080511120910180010900102410705551516050414103112
248	12118161707206101006070810090508100823130005000000120805241454741122104301
249	12107171108406120310060810060909091018100910700001200304941514751212104301
250	1212110161321103051110000809110810083312095030210010050484055040413105221
251	12111091500900121005000408090805130826102730100000020304158404003112104302





252 421282123102001207040807110907080909341609513020050204225258606560222104201  
253 1210718191121207110806150508080906113611271070500100304955354341414103301  
254 421192013122071210100810121008100804371354321090087206165707070112108001  
255 1211312270840712101006060808040810041308270010000011110523648383232105101  
256 4210718240830813060908130909050511020508271020100010100605359557312103201  
257 12110151408405080610110808080710060923065031903004311024543564057112104301  
258 42118202208411080810080612080810100826132740906007220215752624851414102803  
259 4211223231030091006080808121303070919082620800001100514758525645412105802  
260 12109181810400060810061112060610090433120031508011330914058524041422108304  
261 42107182310311060505090810080712060814073311100003140705255604045113105121  
262 1211216206105070708080908060807070515075311102000220805654495545112103111  
263 4210709240030909041107080814061110052507004020100500604748475652113108321  
264 12107238083030506100607071004110506341024200020021003156607225751112103302  
265 4212315210821107090906100808030706051408221080070000704722494828112104104  
266 421032028095070712091110909121208092508152110070100904743523045112103104  
267 42117133710607071008090808060806081009135400100004201516158464050112105504  
268 12109201510411060509100908080807070643073910600002401007261494245122102801  
269 42118072407204110613090213130907040722141420800700200804730382845113107221  
270 12108132212208111009091007071008030723120811201120010503384942451214106114  
271 12117102806412060709080811081106081136110011202002320805887626072113104221  
272 421230925082080413091208040912060410301454216000033050961605060112105301  
273 12109103214112021206100810120808081014110901300002611206456436453113107211  
274 42214132010214081010090708041204081231122710300001230706441516242312104104  
275 1220718211221406070512090010091406113412273030000292050624852557422110303  
276 12203121805010071408080707081108090631112711403000112113546523846424103101  
277 422061222121080608120808060806080813042731506007130535646404052114104101  
278 12204081410510100808100811080707130813121310900000700125240456245324105321  
279 422081318093101009060708090608050508150952219000052310152447485117106211  
280 12210172208406060910050704060711071046114800300500100914730434053114105301  
281 4222723181441006081411012060404120835204752000710011127065656062114108312  
282 1221612181430907101110120612051011092307270300000240804748535252114109814  
283 42209121711200606081109090609060807350927101000000605537566756112108304  
284 122071521030706081308130608070906083306520090002000703348565445112104302  
285 12217192207070707081207070907080735072721002000601105456546262412105104  
286 12220181909212071009070711110508071035090920501002710615284596061413105321  
287 42222041110313071106050411070604070920040030300001020303648284045122104203



288 1221716201040708070713061207060810132013261030050020504048405141222106302  
289 12207131314105080810021212120611061222102510201001211104240354449112103201  
290 12217122112310101214040608080812082110092070000120021434852444112104304  
291 1221814160940502100708071115081008103913174010000204000413644444112108503  
292 12204151208307071111070606101108090921091500501002101015550486055322105101  
293 12209122012108090810100404060408080427162710601000410614555494150112103101  
294 122131018094090611101008040808111110311130110200013090513238444112105301  
295 122181316064051109060910080906150608351303200000010040514859444113104311  
296 1221112150911209081011070610070506101604090000000020021324138443112106102  
297 12221222504208060606160705050306120242085451305006711625265655662448804104  
298 1220818121030806100810101008080806082810270020200070102614040434112104201  
299 122111434066060706121004050410100827102700800002410615651524852414108301  
300 12224161407310605091009140607081108260900304000330104441535250112105201  
301 12218161308203091005100012120705050623061521100007300513641495447112108201  
302 122041415084080508040707080708121061209090080200000903840493345214104101  
303 122210615081061408100808061408021008220418103000030050455634863214106221  
304 122051732101106101008100808060410081407360001003210315347544850112105301  
305 1221215151050709061211061206070809082307090010200000604434412031222102311  
306 12214212308104020207040305020400020519122741800704330536550555262112107301  
307 12210171208404061170081107051105101014112741502004130416560676255212103102  
308 12227142110310071012140606060612120626080930600002510726758675267112105304  
309 12216151210309060210140406060604041028120910800003110735262575165222106321  
310 1221815270930061208100409060507081217082700405100340615852595267247106111  
311 1221011181210505100809030908110509081406301000001000504148515258122104301  
312 12211102612310120608050406060404062814261030400203081486457435447106301  
313 12214062006311060810110710030507050927083641100163100625160635654538104201  
314 1220713170640812061204081110160806042415156000001200524848476451412106202  
315 12214122510210101008121408061404040424074410702005721005152544138112105301  
316 12208142608402100609030812100604080631102440700000100405960515847112108201  
317 122191927125130903101216080306101405251254414000044308170707070534103301  
318 12215142011409120708090905070908072407030302003400435143474048212106202  
319 122120913103121509070805130805051010170700010010000504235323035112104201  
320 12207100808411090708080704040502080424104100400010110634730394442423106302  
321 1221411230830605100808050809070605082511000400005010613938565152314102321  
322 12223161206303070606080204060408060611125411801108021016040454761436107301  
323 1222014190420306060908030608010612071412270110100720103575659638113105812



324 12219152503210080808140402080806100225145041802005100516558657070426104302  
325 122080719123080906080806100806100612201020100000100204741434046112105112  
326 12210172108106060602060204040602000423103021200002100403957475061414104201  
327 12208142106202080406040402060600040620053620901001201113129525852424103102  
328 1221016231020806040808060402060004024308334160200231091596150715112106301  
329 12217161911310081012090203050409110230114401100002400915366636271112106301  
330 1221208240840006101010080806121010041309391190000221092565559566212107201  
331 1220207251050610100512080506080408093010160000003100324450713458122106102  
332 1221014240430606060608100810040808062010210000001100216371463751117107211  
333 122161109123061410080606020809040608250738204020023020044525862261112105203  
334 1221514241221005081204080810060408083110382120000120091666344545112106303  
335 122071418124141009101203120708106102010180060000311050424238444213105301  
336 12209163414408090910110809110915131515080900000110021504424030446106311  
337 12221191706204090811060810110606080722091820400005300125455455561226106213  
338 12214122710105101012100508060204060626094931201011201316683647171112106104  
339 12208152310312091010100610205060702092912270120001001104147454041217106211  
340 12220162908412100610140604081010120820122711000000030353565135327107211  
341 12205121908311030811100708080911007250626411020082002234303135580102101  
342 122091727084071012131108060709071102081400102000000205546524650112108301  
343 122131027103031008101410606081214062115190070000000205871715348427106301  
344 12214162211406071111070706090805080821100900201001100405130444137414104301  
345 1221121280406040206060408080402061029153561503006230727042327070112106202  
346 1221016140710805040307020608000503031107090060000511051605548404112103304  
347 12202161106310080709090407050809070820082710701010200314344040474116106102  
348 12206101407111008080808080801122309271020010623001505665405112102104  
349 12208151910305060710040302070509090725090940300102001224930576058326107301  
350 12209102407405030606070602080206110416095441000006220623870526260412104202  
351 12207181407305060810040202070507090725105441600107600725553515058112105101  
352 12203152312112060810140606100408081236083320207007101325240594765427106111  
353 1220906220630910081011100709040704133708270000200020503131344550114105311  
354 12209182009211070810110504120710090629105430202105210504550545260112105101  
355 12212122112207040609080410070512111123175311301106020425756506351422106201  
356 12217162413209130811110805110808070818085412301005021106660606271112105201  
357 12227242310307080810100808080808101224142700706004031324554565150122103302  
358 122151407107100410091204090611051118135401700104830526371565662112105301  
359 1221810301010091111111010080506080626135411401005050704850625757122105101



360 12219131806306141012080604081009060639162801003000650302937375051112104201  
361 122120820104070907051203030709060510211742011030032107251515140112105101  
362 422112210021090805910061005080406082713274050200601044741434031412104102  
363 122131317082070707090810060907040734134140705009212346955544641414102104  
364 422131215073080908090709101006090843102641600008301945055595854212107202  
365 12210121608305061206110908070506071016122721702005300503641313141112103101  
366 422091310110708061100809020410120508080912000004310606056565251412102302  
367 1220415130420706060607080706070809070910062150010322050595967636(113107311  
368 122171312121060810131207060609080704150902030200213053504148505117103321  
369 4221415141230311090709100510090908043115083080100240406262605763112104301  
370 1221706081021103101110080511060515101804094000000000104541475350312103201  
371 42207111414007070113050705070710110914100810000000000504349435(216107301  
372 12212092007509110606070907100907081026080901300000100604755515648322106203  
373 4221416191420710081008091206090808031211534090000052308244414848422107302

374 131161528103111070706070609050707070717163640000002040424437373048126103201  
375 43124112310409091106120613101210080422095331603102320605254555653113105121  
376 1311018221221208061211081608101008051814273040000342021505029442044103101  
377 4311215200820101410100605080806080426105421501004300245439425134322104201  
378 13116142012210051206121004061004100427125450405703020716150535340412103201  
379 43118242608214060812100405100408120015075440906003340824758565642112105301  
380 4310923180540812109060810090805070810050011503001011902950484237222105304  
381 43131292808410100810141216060808023219096180570906142718171646414104221  
382 131262127033111080412101610080406102409544060150474022636626460113108321  
383 431121424122140416101612040808100806251554305014060006144350424(414103111  
384 43115212900407120708050811081110060729114521203000430414630342037212102104  
385 431221528104110406101213090610071206251136310040083408062595358424105111  
386 43124152510310030410121410040808100621115342005008750915558515250112106211  
387 4311717241041202040814121004081010062510181130001144101435434644112105301  
388 13143213612508060410161412080404060234185432102708440705281535351112106111  
389 43120202213311070614101509050413110427201831409766230605851464138112104202  
390 13126181512308071008111109050510100819150051700311930816686667162212107303  
391 4311712007206101010081110060806060814185441204307730205847606154112105303  
392 1311915250430904081416100406020612103010442205007921016250574430112107201  
393 43116233008207100208070612080810121024164502002004230915954574456112106301  
394 43117122010600110906070510071104041412142720502000000624341345650112103201





395 1311716170760606050810080808080202060722131040001004600714451484444314107111  
396 13124231906404100606081010100408120628105400100002410805654443855112102304  
397 131131614128080808100810081008141610350727000085000506147574852112107201  
398 13112152408308060409051204080310121034121510104002110614336524448322109203  
399 13120121707210606110805090906060506191306107020100230505241574452116106221  
400 13129113315408050913060907070209130724175411208709701206472635661416105201  
401 13136192304312101014160806060208141221103011600006810914336493647122106204  
402 13134252810408021014141008080006160230245461706009610926764635250112106104  
403 1312513180920080810131108090616091419083001000000410505647576752112105204  
404 131171817102040504080206040201080517111810300004130214347444452112108301  
405 1312218231220512040806041006080606101514530060200500904336524448112106303  
406 13117172210414080806100810060610060625131821103008820914351554447116104302  
407 13115192113309081011090911061307150831165421801009630105262535850112106301  
408 13125122004108051009080811060509070925140600700006130403856634752112106201  
409 13124152713306060807100708070902140524072741801011421203853545650416107324  
410 13115111812510071010080710100907100717150921400000633110503555244322106302  
411 131201821071121213110709040811060721092700300012301225534514640112105202  
412 131262215051008020808021010108061228135351503511031106348665252212104201  
413 1311218121021710070908061112080909121909001090010906060534746404216105111  
414 13138142710311050904100305100708090928155431402013032307171565447412104301  
415 13119161712213050909060808110101109261254013013071412038593741314104203  
416 13116122610213060809050611080606090717114130502011130904450495450112107203  
417 1312202612306080910081011090709081022195461106110941316370617060122102202  
418 1312217221020404121210101110909121034183541804115841517060615870412106302  
419 13112141807406100610061007081013072611263110301110714648455456217105211  
420 13114202913310050609090609090707101031115431505107721005136394636310107301  
421 13118150908307090311100807051209120317183910700006160704544353030122105201  
422 13123152012307110906090809081004150722175420603012141103036395044214105311  
423 1311614150210090808141011070807080424090921601109131116355505648112106102  
424 1312218230920809060607121107070008071612547160501354080585670626064802304  
425 131242031122040408060504020202060236143632204211120523740556050428104112  
426 13112101614406101201060608110808040645092610102006101005046504020312105302  
427 131161823090010050811110811040703082119270907010211307155666624106211  
428 131142623072120408060808110814031227185411100108141613736494945112109202  
429 13116162212406081209070906090806080721093320300000201104362455160112106203  
430 13111101810104050807100707100810071117135420001007310804362423550112105304



431  
432  
433  
434  
435  
436  
437  
438  
439  
440  
441  
442  
443  
444  
445  
446  
447  
448  
449  
450  
451  
452  
453  
454  
455  
456  
457  
458  
459  
460  
461  
462  
463  
464  
465  
466

13114172503408100910040412091107070723125450701106500314840385045112106302  
1311309260721008070310080605090807051808270100000211204350453554112106201  
13113142103061007091209071103070306210630010000000160504640340112109201  
1311311270830610081009040410060608092613423010200200205453574558112106101  
13112091809106041214140907050404080732122701103013120215153453540112104101  
1312110140611006060616060410080406062215502210500923070475150455112105103  
1311413300230412100607041211050807081913091040000300000545353550113106221  
13117151810404100810081206060406081026130930505009230616358645338414104101  
13119101614305080609121003080810081028175450203107350206671595552122104101  
131161721074081106091106071012040710231409600031042211047885540522105111  
1312012260820800808140610140814101032120000401112310413938483737112107302  
1311411121050909091211100604120804081413431000100100603134495445112105101  
1311315170840004081007070507070221064401003108300105551645452312106202  
13114132807610090508080911080909080334112721203011400526359525054106311  
13109162214507101006100607080502091225143661501503400405352395154114103102  
1310818220730713081109080709081008103209412220560823131616139513112107101  
131211728105000900609131010080909052213544050000831051454639475041410111  
1311412191048101007060606120505080630183420502107310416654616657112103502  
13110131910205070607120508060808070916125140703109230814255645360112104202  
131231519086020402090909060504091004271508014020002207255854463112106201  
13123161515405090306120709070809130529120620904002301004841393130414106201  
1311820300931202020814130408041110062209442170120900111616159552112107102  
1311815211210504100910060604060614062615542210211132052695548485112105301  
131121308104100708100807071009080710200747114030100105043413141216106201  
13125172509311030400061106090605100220135142009010341125350645754222103102  
13117131407301130908050614060507061034183332004013600204755524854312108302  
1312324221160907051010120511020811082618094020707331715564696060112108201  
131262527064140508050705140603100506282236622097423000645514248322107301  
13117221416310060912090806110409071136161800702700200504044553943424104101  
13114131812508090908101006081008080621083640010115331004341353742412106303  
13131192511509110910130907070903120622125421200710020904150494840424105302  
13118182911513040310121111080504130427095312204013720515860575054212104302  
1313018321431206081412100608110812022105432405004341605548605635216109311  
131292027121130506061104080811101009401243219000042508160557070222106302  
1311922191141010061114110407080609091915332100170212090494860304112105101  
13113162412206110811110506101007080528085111602004230703540354244112104301



467 431172023064030808090908050707070706241154312041033410042355261402171033512  
468 13132141611306080908090712080709110412112701400706120504530485135117105211  
469 4311222230820909040101109060808063515270150100824072525654260112106204  
470 13126162208412110808121309060913120630095451805012202936657555461343105311  
471 431211132312108080812130909051104100828115321101104100935137534251224107211  
472 131121918073070706071109091212100732105460802506200934029374634112105102  
473 4312119300630509008130810070511070623094741307004300743741344847112107301  
474 1317422180821010061212100408121011021165431901308401643445392945112102103  
475 43132111413210100812121004101008111021105341602509301044857715763123107111  
476 13123172408209110608120903060809100512104240600312211236349575050112106201  
477 43113151913110100612111004081008091017143820900307111044583453212109202  
478 1312418171221406101111006081008111013075342001506301644243514030112102302  
479 4311316170831212070912130906091212063809271150030202024439474441110108301  
480 43120172012303121010080810141012070729075461600304930734757627456428103102  
481 43120162207309050707090511070510062085432203006200715047383437122103102  
482 131242529083120608080601006101015082113546170700942737171665950545107303  
483 4311622240821009031014090607081007103909543220610700172538050414121000601  
484 131162311082101008090708080505090745135431005007008161614861216105111  
485 4311925140040705050412091007050808083811275090500472092562475350216705301  
486 131191722100120710101120804080812042315271080200411414952474848113003311  
487 4313619171031080212101006080808040221225451600006101215647524850212105104  
488 13124141808208100806121004101008100623135441301405401525452374843443102101  
489 43116142308310120811060610060810080625155170900003601503030373030312103102  
490 1322314220860804061010060608061010082614272220200225115656617267524703113  
491 432221522122100808101008080406060906130954400000633005340536757324104504  
492 132252022113120808101114080404060806321254419030095207072647263722448803204  
493 432241614105100408120808060808060225115251304010440805564676164114103101  
494 13210051308208100804080604120206060417090011100004020404351415542112105204  
495 43223163000210040612070509050710110634125401101008400804349396062212105104  
496 13217182212410941113140614080507080831135422104009010704336344457222104202  
497 432506090831006081209080706090708091707030000000200504354284438232104201  
498 132117170831011100815060506080612032208541100007221205045525254414706211  
499 43212111812308080804160706061012120419095411001507621815634472030422106202  
500 1321811080630707100912080611061009112914270120000814122443949514112105101  
501 4321607230305071011080605070710040837160010401008140116142374431112107302  
502 432618180810308101608090707031407031616544110500574112596259625424103102



503	4322222170841007101210051210800100839165242263012041206666717171414105203
504	43219091510312080512080809101008121019120330605007531705355616666122103201
505	4321008190821004060810080806100810062511440902008250903842424441112108202
506	4329242410403071012080708081408101322135421600004221513842374251347104211
507	4321515210910807081106090608070807062411543200301100825052545042414104104
508	432121822082061006120606100408080610070909404011133220614052586558412107201
509	432191220091209070808051007040810063414540140201412071606565546522410522
510	4321413140810120811080608060510080631145040702008100715360484462112104304
511	432201124112101108080409110911111042615093100104130714941454640217103111
512	4322318180811210060810080810120608061306543110501123071488051605432105102
513	43206142112404100704080611060408100816101810203000120615053475542424106302
514	43218131808309100408140914010408061031092731205009030303758606255424104202
515	43213102506405120911080807100608060925062610703006430905650525450216108202
516	4321807140431060608140810040810061434120830804009330405245574747427107312
517	4321011181121007080811081102100708103213270000000100905640474040312107101
518	4321408100810505106120604120907111211112000000020041504850442424106102
519	43215141910409021310061010080808061020165210900011210514963554446112109303
520	4321714220941000613081206140706080730091811700011200713948564453127704211
521	4321212231040708121009111090504040827120010501106300405840305141217104111
522	43221172000509050812120806071008121413090930200003200625144463041212106302
523	432160915062081210110905100715060712261209000000100403134493131112105202
524	432131025113006031121006120407040626113211603005300605855595657114106303
525	43214102508203080909120912080911071022101810501002300403946514750112103102
526	432192225073101306100813091003080307321645217040156212048717171212109223
527	432151422063039080306090706101100413102110402006000213636413631112106311
528	432181921103100706101010060308100625145121707213200815844454850112106302
529	432191627082060905100908081006081004221414200021152101364754666112210302
530	4322220201241011030910111050011070919092710901005331316555503540112105301
531	43212201812209110310111311050012081020072110401004120113858484755444104201
532	4321420251321206051215110706030914073109362160300422091584546505316106211
533	43231232410411020211141212050406090320114840201005220524560544744314104211
534	4323219091041011041310131106000907091516272120000030927083555646122105301
535	43215181410204100807041212040904041015123630302004230725465416154122103201
536	43215201800206050808070510091105040313144221601005720934051304751112108101
537	43224241616310100711110101050808110542052741906007031245760715020114103102
538	4322218240031210071105051008081007081717363100300701083624855565333104211





43233242113306060707100908080506100828135462109506331336066496261112105301  
1321516170930312050808070806090605082112456180300551094555114853530416102111  
432141923104090809101110070909091023132701805004221344962436252423107311  
132081020113070911080707060507030806241326200300120031295129503223107311  
432192120112106080612121060212081032125461803003541445254535057438104202  
1322127121011061111080504080810100414164922106090080595959505112105302  
432090916102011060610050212040911032913154120500400814639475543112106304  
13210222313305110709090907030709101224115271804009331025252516057546105304  
432312423115080709070910100702080720095441802002008065656567034610511  
13213151012206030610041002050712070925133230600000910615344566055122103201  
4321619180720306071008090508071010071211094110200300903652473539116107201  
1321813101040506051010071307050708051608093040200012100364445464112104101  
132262618084060709140906060708061019133041900500900504335374845416104202  
4321008170820610060707051003061310052510091000002100404852533052312104211  
1321323261221308100608100810100810122309090220000620344056544757322104101  
43227315271040305040610060710020812081914544140201323143604549504112103201  
13233222110712070410121204110608140224112741705011221425660617171212107302  
43214133012212080608070809060705071026072751002107100913750455858112105302  
13217212310408080805100804080804104311309413021078093395047515414107202  
132201426104101008141008061012100810101454414020042171552040442212104201  
13214223212112090710061005110606081417111800000073205050393747324102101  
4321617271211005080205040610100307062810273070200183054565757304322102101  
1322212200841408061006121020212100622173330500009631124871575557112103201  
4321923240700100814080508080412100825095440700002700334834454051312103301  
13216102611410070607090911040409120741101911603000300614254426053112103201  
1321617201231202080408121002080612021421541134012200625350523448112103201  
132231713030608100615040080812080724083821400006400573444374550112107201  
13213132142310041205080804090608090827195041601007220926663626162112106301  
43216192011514050613110808080706110716130030802003240106263635548112107201  
1322011201021103111310091108040406052911152100400031021565660505112105201  
432211731104100507120809120809050053012122040200070050515346545112105101  
132191222053081006101010060908101010311629102000010004047504852412107201  
432114221010407060808121007010613072613005110300521204940585560312106301  
132111161030810091009100805041010061514272050100050034852564661222105201  
43222061410410060608081212080608100414122920302104400214941484138212105301  
1322415141030804060810081006060608044415095100007030505240555253514103201



575 132140722008308070050707040609041107301128115010012105047444040471112104211  
576 1321113160911204060709131106060909112015155010200630503430434447316105311  
577 132121219503070807121310090409040808172119313010041114034344534314100211  
578 1321408070830070910110507100905100738232751801207400504654515455212107301  
579 132101029084001008021008031010080610201145405000040040463647464412104301  
580 132171025114050807100503070708090509181325070000762090464844058412105301  
581 13211243007306061107080609071109110619195421902004040915850586262434105102  
582 1321715271020607061101110710090610091016090020010100505340545052214104104  
583 1321712130531108080908100806080608083818073000000220813720474431524104101  
584 13214071106213101109111407101007061015102720402009200103740555748422104201  
585 1321012150030070909090903090804071110130630800009110705140474440444404214  
586 1322123180721110051209120607040612052610240601209100714720536151317104211  
587 13220101607209090708110808081108090932083611106000400935348505454413105111  
588 1323228271340806100710080808100310071313541230501004231576258671442102304  
589 1321715241231110910060708040613080716140941500000093070636370065112105302  
590 13223324161231107071013120610081014061412546170100103100717171668122109311  
591 13212102708310040808141008061010100421143610201008121514347475060222102104  
592 13221141302312110907150505060807120623104720401006301404954495055414106211  
593 13217172508211050812090911131108080921094830500009230513647374840124103111  
594 1320712201220809100812111010041012141812273050200843080435440504414104104  
595 1321215220109030910071205120904060616173321703011440305181445142312105104  
596 1321214160831004100612101012020404081315546170400342050435047524542104304  
597 13216141208410080808100610041008080818193620804002300815150385930112110202  
598 1321509191040606141006020606081010061510330001008130504947535145132103204  
599 13211062708310061008101004060608100416121400600012200515144515350522102104

600 1411192118042081010100610091007101430105320703315501304240434130558003103  
601 1411909022204060610100808100608080828115321104011700804842453643112103201  
602 14111242410610030410121406121008140435115441407007013149634360217108311  
603 1411512170820412100208040406020406042009095200200630903641395848113106201  
604 14117132310206081208060210081006100633145411903007111103636364440112105301  
605 1411172210512061006121210080806101021175402200009510904252475548426105304  
606 14132162308603040810120810080806080837232711900009601905555394052426106304  
607 1412519141041206080613121009061206123109544180851233090485856505212103201  
608 1411322280810912110806060408021008042419540110600921813687474043112105202  
609 1413322241220612040808061008061006101310547140400540191465555148412105102



[illegible]



646 141261922092020707100608060610050706111754332205112031205246516045313103211  
647 14121162200315030510121111071202080425205321801510231105057534240412103301  
648 14117142608400806100507110410712112913004000010621015237553732117106112  
649 1413321210260705020912101008050610041819546190610906122636165548212103301  
650 141262090430511071013100310502100727165421103003021406245413035112108304  
651 14165212512500101008101000091006101038375151706708711216235625745322105301  
652 141332518103101106111506062106612092517033210810931425750466262442103204  
653 1418032291641406001416160810020812043659547221371708251688686868538103302  
654 141151419135051311009090706070505072614501150101111704543384141112103301  
655 14124222613310040607091008080507090425312741902140310515535465151113103131  
656 14113112606412110606140804121081406272220902306210614854505953113105221  
657 141232122145101108121112070602080709210854322017054313263548565226108201  
658 14146232614510130609141010605081402223154321090069717371717171434102101  
659 1412221231051108070910130607051007124310544190500232072605665051448103201  
660 141252315103070314121504071060809062017272190470703062525550504122103201  
661 14121192210409080913080707090907101009105220607009431246666626056113107321  
662 14135243301441508041111609040308110315195341908707932030508505358412103101  
663 14129222307009070607091110101006100837115462104004801914755435641430103101  
664 1413230230311070807070908071209100736135342306504011406862684652112108302  
665 1412517200920708091011071009070909073211545130250893170573248384322103201  
666 14128202403317080710100606060604080623085462202003021205550415345213108321  
667 14139282914412040614100610100610160636140942204509031305957325150112107304  
668 14123232400406090809060708060705071037155462205008030524351524232313107211  
669 141181817004050608141010100709210092708276090010210081324138323842102101  
670 14123230011303060608121109080810030928155421703410831023846484947112105201  
671 141242826003100906110611081004031000718094170650421404138526257113108321  
672 1412117191031004081105090070507140429145441501110130424768454651414106121  
673 14130202702409080812101006061010140425123652203701730425563565756116107201  
674 141381021105111304111030310513090329205331602007020524470385245112106201  
675 1412816221210805081006050090804130621202731900000730904946303045113102121  
676 14120232112112020810141608060208140422232731904208051415563455458312105101  
677 1413321171031005081010001111108102517544220200384090425648456112104201  
678 1411213241213040511121105050907060217143651604005610503838424861414104301  
679 14122203211306070606120611110908060840162741905006250723030507070424103102  
680 141704210620909071214081203040408063312273060050163031404424031213106322  
681 1412221230520909110906111008080711043116273190420563100485554505112103101





682 14143202914214020604141204080408120227184542207003010435549505952434102101  
683 14144191712314040804100806020406090918150932206708040925143574448214103102  
684 14131222412414020507141208040808100442215461908003051525347314745212105301  
685 1414114190920005090605120706030708072518094170570603114131393141424104101  
686 1413123291330508120711090707101110630220932206705041226961444041213102102  
687 14177302314312100809121308050710080626245462005403070835736523154114105201  
688 1413125190631014061308100714001412083221455170500582092494654525414105101  
689 14131222314511080811081004070301100921222430906107210040337525451277105312  
690 1413223241431104021612140804011012042521545100700739160375403742112104203  
691 14127172008410110711090704050910080943142741303703041614248495047412103102  
692 1411407151230306040812120806041012042515253050310572100544355473911310411  
693 14127262206306080608081010081104080829115120904700630915660493952112105212  
694 14114131408410110711090704050910080916092711000606700704760615048112107202  
695 1412511221241013070812101210040808043512533030270431092575855656122105104  
696 14126131507407040711100904060512110722145222303704621425850524734212106202  
697 14132253411414060608151008060810100421435162011703040917163716271112105303  
698 14132233212307060806121204060508120544125432205702631234643422948112105201  
699 1413202312410110603041306080710100942105451800701730632946294260112105201  
700 1412714200831040610141013080412140525113131103705640423930344141213102311  
701 14128201807300809100807080709070725122731303701801002920463440112107211  
702 1413916171251410080512101007050708062211274140470454050442464760226105102  
703 14128162111103081109100804041008080819152741704705030906371594058112104101  
704 14173152696205120705080710120608071212164231101702831104941404420424105111  
705 14131222010309050807101008090509050838263661902008050816657576142414104204  
706 14146262400512101008141204041008140626345432205709821115242596153412106302  
707 14143202304060805090309080410100830180942007416012204851485160422104304  
708 142582927123006061012101013020710063814367160930751120706470707426104102  
709 1423026170051305131010070905080910063410543230250603082535355424113106321  
710 14251282113312070408161210050906120835295431907009071325960646461514104103  
711 14222141912009040710121014120505081028100901303010320905731504158428104201  
712 14208211514207100708100812060805040919115330206009430706444535160422106304  
713 14234161507207090413140809110607110735225421904004020907048605164312105103  
714 142171418142050907080707110607121024091800602008100716058606245446102101  
715 1421617140630408060810060404021206042511241160005711005753605148113106322  
716 142592218135101002060810100404120810351754421000583040528360675222105313  
717 142131122031210060414121008060810061309000010000920080534450473116104201



718 1422018231230061208070810060210120427151871004110330804845434047314106211  
719 14217071500300603080909080805091126152741102005120604836363647312104101  
720 1422827120030090410100907050805100540235422206003021904456594850317106322  
721 1422315151000702041006050408110811121609512140071214007121704342514251414104101  
722 142091208121061010031008120810101008101322531009109051513942463147424103101  
723 14226201616404120909041106041006081234165451505009451504654696051212105304  
724 14226161708304111006100812060808081027175331704010731105762615447112105204  
725 142262023104060908121110090404060804110543120500622170456064504122105204  
726 1421713160911014061010040803081306063202700803108001904942453641112109304  
727 14231152010211091008100810702071302241244114053096309055554052417104202  
728 14217200900310080606101206120810120831135421506316521615160636152212107202  
729 1422120211650412120607050808100610122417122150340823152456374740114104302  
730 142262011142001108101010100808060825095332205315521414550375153413104111  
731 14219122110310040912100008041112100630060940502002100606040476060112106502  
732 1422216170830080613060205041206080723112501200202310504148324643112104301  
733 142312015002031208091101411081013142616532230101327070686805768216106521  
734 14213121717412080708120713120803080733092731602203351104532434037444103202  
735 1420507251008041212101008101010123409342110001305070405576857426106101  
736 142351221004170506120912110501101407161409313011172041447325148426106312  
737 14213112117507100502091300080709100427010427012741301003100213535485451414104201  
738 14210182310212080408081212120210120430175122000513130704845566042424104302  
739 142232722003120804040810060040806103223546190300600130350435050436105103  
740 14206342510514040810191206060606100540245462205006041103964544538112102301  
741 14218252514212060608121208100606120231105461306108301205454593862412105202  
742 1420919211460008040812101007040610062178442220850782092566450426106302  
743 14206232000310060604100608060210120815165471600204620604457514050122103201  
744 14208101613400100810120506100806100620215401900004041004844504052434104113  
745 142171920112100409130410000705070008250954516022090011052544040404113103121  
746 1422326191450708040612140509020810033517544220005240405756326250415104321  
747 14218201507507100812070706080212110815092720601003400706157565853424103701  
748 14213191400500110809061010060610080818160920601005610715964655435117106311  
749 1422517251231207041012121008061010003124406140300503003741433042227103111  
750 14215232514414050808141406080610080819095461501003740614347474051112104201  
751 14206182613310080414070907040308101034131830303005010616464485450424105302  
752 14221122510212100616120204120804100738243861005008031004847414540112107101  
753 1420724171050050706071007110607141109135472220000671122645059545112104201



754 44216163210514060612140804100608140621103630504005030904852515340424105201  
755 14222102706205140404120806120713140829092720700002020304138456241346104202  
756 442261518123121110111209040605071110401954622075060131303038333424104202  
757 142281630034070600081210080603101406301654717070050112251546255112108202  
758 44239222912415020608131608080810120434125442003007020713987504950222105102  
759 142261614104061008120808060806081102241600414022505100403957534540214104204  
760 4422823160821210060612080906020816043120493220450803050486258557212106302  
761 1421019120830010081412080610080604071512152070100110090394943303112104303  
762 4421009170820008001211090808110810082302345030100020070394158434414106204  
763 1421419161230060808080606100404000823130931503000511015951554047412103104  
764 4422152612211050712081205040812090715175471504005430525345485147222103301  
765 14218201912210100710120810060710080621073131303003430924730423545214103101  
766 44226191912612120512101007090706100421090901107108600514548626550217105311  
767 142221328123009040811121208071008041413544003005740833045535450122105101  
768 442239131912112100612141006060608120221155440904007600534651586062422107301  
769 142152420750908101011120608060407062010183090300122032354855424112104301  
770 1421917190630507100910100804050206091812452060600373092414153305113104311  
771 1421332191041060710060709100810060825091821605306300524145354535214104211  
772 442192120001005041013050808060408102610440130510302062524148515147103211  
773 1421516221110070407111305081008120624102741601005510515360383038427107311  
774 4422523190661109081212110806050812073112254190300303051624059686414104202  
775 1421517190911108081107080707071008092909543100040071031514362565313105311  
776 44223211710610060408091205070512120437115431902005821614746575062333104111  
777 1423013141040011090510040605040806112812454160200845145048483835412106314  
778 4422815190030030707100606091211120926152621802505601313552353851436105104  
779 142251824104000804060910060803412081811305170100360142544455455124105103  
780 44226211510310100607061208140412100620185441900007861106337524850412105304  
781 1422913270241208070812140808040212022218185220231065102624060656112105304  
782 44216181513308080808110709070410050735105351301002400015152626145212104203  
783 14218122216106091209110813040905080623142510800104751314552483845312103302  
784 44223131809040603061010100612071510062613274150210704081584858561212105201  
785 442232119036102070410120405081010050823132520801200101126030504445213106212  
786 44222161906306070811080909090713080528155451603007001615250525745472103202  
787 4421820200840091009100511090607160929185341906010041524560706145112104202  
788 142242211912410060406160806100506120626142751706005621216544625145322105301  
789 442222211040400041412061002101406322454222080060309261646161122101102



790 142256262914012060810111206060308080620085451303705431223151414741434102302  
791 1422917250806060614100406040814042005422010700231624350365248117106211  
792 1424224221451410060912120050308110433205442304704092015550695060112105101  
793 14222232314313040814141004100312080827265432007106930834453484745112105304  
794 1421710211031005041214100806050416063207544150002030424640525452312105101  
795 1422223100507041308090408070810100720063342201004010923956445050312101101  
796 1422918224116111005110140090507131221135440710004840725056595050424102101  
797 14227162208310100808120810040800120619115421203506520824754444330122106201  
798 1421710151040610040808060410080406021911092160500403183364048403110104301  
799 142402628143141202081214100405041008301754320030030304061666671601416106201  
800 14220201510107050708100912090610101038122722202003020505053556756112104202  
801 142201816053100606090708081209101113010361190001030914148495150112107302  
802 1422419211030611041010008080610120533155441701002400813048495752212105302  
803 14213072260841207091109100907050910100992600603604220403045424250123105311  
804 142181722510308070813141009060209130825131231404001440703848485052222106202  
805 1422008280641109061309060808040910081308363080300300304938525670216107202  
806 14218261808311070508121007090409110934154831502009730806030870470212100204  
807 14224191606300060809080705030211100644124321702412521215550556140212106203  
808 1422312221530810091012080911030607112207410120320336050485045461434104202  
809 1421618241410710060613080508080906161554309040073209140433373252112109201  
810 142172117102080806140512060808040822103921804403700805450624148112104301  
811 14222241514406070206121005090408100817105452203110300804846595450112106302

812 1517328270051411030812120007070412033311254522125140316470646467414102101  
813 15141202410508060810141008060608120419135452102214020745854585260416107201  
814 151312122021108040913071105021411030175242205209041515348514236112107202  
815 15116182500410080714070211070307100922123350803010412314744553041113106331  
816 15130223003001008090803081106051106261254220060157408262584340113107211  
817 15120253006612120612130904070506080441124261702108040923851304150113105221  
818 1513720251141205060615160310091010223105451405512041103038454040112111302  
819 15178252802212080206140814081010120641105461505008921815148403030112108201  
820 15136192812511020412091208100310120140192762006111070725644513040113106201  
821 1513415181050910061013040812041010800155431405116841814462534050112106304  
822 151131727020406071113120908020914061716546150101020724236474438112104202  
823 151442230125140602101614040602060802191827615042056110136415648521610611  
824 151341629106110605060906006010612073020542240671308125666066606113104121





825	15124242916510040612151404120612160411225452208016051934251505140414106304
826	1512524280941011090710130607110707101619541200100051734234404050312103201
827	15135262910400061107081009040406071236235251407310051454751535141414104312
828	151382626083000605090808080610044165442108218061753447344734122102101
829	151231626082001111508050706091101120095430906008721104238363233112103111
830	15127191710308081004100606100814100829155412208011051704540464551212102302
831	15137232512300090811121009060507140829205352209709021026784566267116105211
832	15139242411509070904091209080703090629210942204712560915355626062112103101
833	15132272512410080806121206100204060415265412103710641035853675854113105121
834	15115192812308000408081208100208060407205321604709241124747465054113105121
835	15127192306500040406101006040204060620112732107010931206284535358113105221
836	15116122700406040308080406090507040621132741907012721104943515047113107211
837	15120152100508120808120809070710090917144350801011230813851495147112104201
838	1512418180020604020508060404020206023413533130600955123558564747214104121
839	15114001708306071208040505070510071020120641504006530915143424238213106121
840	151221011103111120110120708110605143110090050200720110434843363112107211
841	1512426230514060605120906100412100433165442207514461725264525242114104211
842	1511920250420506060812130811061005063221344161051231210364336484212105202
843	151312118121070505101005121050807092712543210611551114836484364212103101
844	151282231105100608120910101004100226160032004516331314938436751112105101
845	1513230230640709050713120410070708073621544220900906210544633533122104301
846	15120142106514060606110906080508100415211720705013230815155384755112104202
847	151314220820071011081007061010050519195332000008221106253624045122105202
848	151310190808101414060604041210061415331220011443081546458451316104211
849	15122220930005090708091109070612072013543190202154123385043404748102302
850	1510021180960415071203060609071110103022365170601678113458556067536104204
851	15127202112209121066140808040404120826195431608512120804280513058313103111
852	1512805181030807110613080410080608101310270601413790413337473742123105131
853	15132142206207100813111109090609090423184950504300240906034603457312105202
854	15120161007306120110120308101110121213225431908310821614740364445112106102
855	151225331141408011015120208020914043629542241071609183668666506112106102
856	1512421311320902100614160606001010004415485190451040505054476640213105121
857	15124302512404060608101406080410100853700971809712701645660566045112105303
858	1512812101211405111014091410081010012508260220520220503447504734112106201
859	15127182312214070610131206100008120639205441906005010804843404048112105201
860	15117172710309100811080809081110130922125130306002410025045534735212107301



861 1511621201031210080913020507081105041511545180250676052518556505112108231  
862 1512315250721005070513091105070807093218544090005631004050475243412103101  
863 15143223012710110612141306040708080830295432011508021804748406050112105301  
864 151662325124110051210100405080610045444531612512022305750575060112104111  
865 15151331696406090911091109030507130639775442210707441715970627058113104311  
866 1512521160620611100504091012051009121113546110200513012395746404112104201  
867 15122142412300080608141212106060810151754522057066064557166604112107201  
868 15119152710311040209140910080606080247095452003504721414860505060101010804  
869 1514520240650000414101208020707120834025362002709031425071666257116108301  
870 1512421000508120406040208020606103110502050000573050392029304212104204  
871 15130231814510050809100908120503090715174861305006741223966625540112104103  
872 15108182410214100208100608081006100323180971502508240524762714557112105301  
873 15129122400106081110101210080802080738170942106510050324630403748112107201  
874 15121232514416050610111204120410110829120032202007051825034343020112105301  
875 151152329173100041412060004061002351309220050114610049604457520110102301  
876 15140232407313080410121407060508090226255462203507430634882404138112103102  
877 1510915261031051206121308060510050112125441001203650923756605052314104201  
878 15106262206410070405110811060010100724245452202207541034240446043112102201  
879 1513022210621206100610100814020410082415543210570967112585483737314705211  
880 15129112100210040804101208041008080829135441903703530974957523640222107301  
881 15103310063120804141010101208060606481854224037011312024537554113706121  
882 15107231804307080212060410080602041231155402204005760036641575051010103211  
883 15106342010214101012101208060606080827175441709710061324857304740112103201  
884 151001528004031204120812040604141208201651621001107515234303340412105202  
885 151271726076103091410100209050913042422542160571275132485341404042103202  
886 15102262510710070607080710040408120816205401903105761224080994737202104101  
887 15109102312300081006110907040709130828172421301003230816030463047413106121  
888 151022723123120505101410107071106072323545180771141313442553146230103201  
889 15128242509600081009080811070709040429195240711708061625452513752414104201  
890 15109151906312060704140810100610100821162741304708860705446445031414106102  
891 1513120311541108041412160006030004022424273140830462092574240446054402303  
892 15106132107310070709040816080708110826212711901107740833151463050112105103  
893 151292025141080600110808050401060805222209520031073100404149405112104201  
894 15126111908405070504090409071011090528191821204404030714357465043112106211  
895 1510722331340705031209101204101211072412534170500030604680405440112106203  
896 15123172210815040408101406009140910073417006120601020804951575036112106211



897  
898  
899  
900  
901  
902  
903  
904  
905  
906  
907  
908  
909  
910  
911  
912  
913  
914  
915  
916  
917  
918  
919  
920  
921  
922  
923  
924  
925  
926  
927  
928  
929  
930  
931  
932

45146171217610120512150810111206111030180951800511050533454606367312104101  
151282015101000408121610100310140424212731310013020705146433440212105111  
4512322190650807071214110906080308103221544150700383001666666357112103703  
1523218141251110061016081006080810041710020900007920305930495351412107204  
4522516220030000807090012070311090809142741801015242014856595152416107202  
15237212400310070510140907040607120420114560505212031704451625067223104211  
45231262210506070612080808040807120833125432105007941905544365540412106302  
152062120006140702141208080906080608381254416060093320254544335541426104103  
45257281711611070609160607110310110742485442207517092116470707067117100211  
1523319180050810061008051006040413042820542160431175082504604450414105201  
4522412181050011071111120907070908110918311403011730715340473450430104311  
15238202910214000412131412080310060522245462207511071205656445050424104103  
4523213261061014081210090605081210823132731101015340805752576152122106202  
1522512201250808081208121061004100824125412003110230926457645057434705303  
45225132111407141008120810101006080928090002003015231614742535051315106302  
15218161711410110810060208101008023616481060116231405846495632426105101  
452372525144140604101410120410100242175452100121481236764675162216106311  
15217221712404080806140806100808161028193252103005340605157585460442804104  
1521521181021108060610050812101109092209531040100314040394853546226107212  
15223142306306100908121214060206121011094030803000210504631504050327105112  
452200022141207110811090610110709111809101010000200405930374120112105102  
1522315230260709081113100604110312021707433100220530041543952486226107302  
45212112307310061212071006060110070826131211002010201215431463034436105702  
15216141600007100408100704081206141034114761400005416734242484040414103202  
4521302261030400020606080502040412000090940300006320104561627153113108331  
1521817157620310061209051009090912026214251500003330725431505160112109202  
45210172000414030408100611110810120612083650801007010416352626751442104203  
152062124124101007101311007010813052212274100009300015150465052552105304  
452371921124120503071111209060612071405432105005510715155596171444103102  
15210101600406080610141306060206160821204941701006003316848415155436103202  
4522223241241214080612081206040612022511361170200500116830715153546107202  
15218131816303041008121208120608140621142041403209320516148566640426107202  
4522211261051204060615121206041010100810244080000810102545266575312107204  
15215181300407051008091010040204121228093611303007511414748465058224106211  
4521609210761203090810070610070912062010301030050122042444395740222103202  
152171920124100807070904101002090611130748509000020061575044535422105102









969	15236101908710070309130711040505150706015442102706630536064646156524107501
970	15246222308412000307140605070309110622185432202706741336660696057416104202
971	15235192010610060913110607110707130436165130402705730624046495050114107211
972	1523928280631608060414141012041014024414545200501040725263566346422107302
973	15244213114416040408161402040406120228165442100511071316350616056212104201
974	152422627104120410101312081105101082817514240270901142695269466412104201
975	15273122400312100405101607100406081232104841308204021033740444066312108301
976	152731622122110610121208070406100518103941703010330415750485141112102301
977	15223102712214071007121309080410120105440900408830914248374046312103101
978	15223152514614040208121406080406100222265432106008420715150535240122105301
979	15231172210400031010090510090406120831142762207009050614640585248112105301
980	1523913231040607061410140608061014062419542190001233102404616051314103102
981	1521142506306100708070211090408080926125452103200710934460425637436107201
982	15218182012312060704121512090410100126112741902009720614837503150122104101
983	1523722290614101006141208060204121018083642008007040824054504163422103201
984	152201325094070505091208080807121210619105421704006041115431314131112105301
985	15202182312614070806061206100902080634112830302004340305741515063112104101
986	1520417191150011081009031114040808062316342160010534040603434441112107201